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THE JOURNAL OF THE AMERICAN DENTAL ASSOCIATION

1936

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Exposition Auditorium, San Francisco, where the Seventy-Eighth Annual Session of the American Dental Association will be held, July 13-17.

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THE JOURNAL
of the AMERICAN DENTAL ASSOCIATION

Vol. 23 APRIL, 1936 No. 4

Original Communications

PRESENT-DAY EVALUATION OF THE PULPLESS TOOTH*

By J. R. BLAYNEY, M.S., D.D.S., Chicago, Ill.

MORE than two decades have passed since William Hunter called the attention of the dental profession to the dangers of the pulpless tooth. During this time, we learned to have a much greater appreciation of both the value of the dental pulp and the dangers of the pulpless tooth. Since Hunter's time, tremendous advancement has been made in dental science. Medicine and dentistry have come to understand that oral conditions may be either the cause or the result of systemic disease. Dental education is placing much greater emphasis on a thorough training of students in the basic sciences of physiology, bacteriology, chemistry and pathology. Some institutions are teaching these subjects to combined medical and dental classes and some are giving courses in medicine, both didactic and clinical, to dental students.

With this marked change in our educational program, dental operators approach the question of pulp removal in a different manner from that of a decade ago. Today, the operative procedures involved in root canal therapy have been materially refined. The entrance into the pulp canal is made with strict regard for asepsis, and therapeutic measures are planned in accordance with biologic principles instead of empiric methods. In some college clinics, students are taught to study the bacteriology of the pulp canal at every treatment and at least two consecutive forty-eight hour negative cultures are required prior to the filling of the canal. Such an educational program is certain to assure practitioners who have a better understanding of the relation between oral and systemic disease, who will select with care those cases in which they retain pulpless teeth and who will remove vital pulps from teeth in such a manner

*From the Department of Dental Pathology and Therapeutics, University of Illinois, College of Dentistry.

*Read before the Section on Therapeutics, Pathology and Research at the Seventy-First Annual Midwinter Clinic of the Chicago Dental Society, Feb. 20, 1935.

as to give a satisfactory result in a large percentage of cases. It is important that we keep in mind the fact that some time will be required before such programs are adopted as routine practice in all offices, as the majority of practitioners did not receive such training during their college days. Again, patients must be made to appreciate the importance of these improved methods and not accept treatment when aseptic precautions are not taken.

RESEARCH

During the last twenty years, many investigators have studied this perplexing problem. The methods of attack have been clinical, bacteriologic and histopathologic. In order to analyze the present day status of pulpless teeth, it seems wise to review briefly some of the more important contributions to each of these methods.

Clinical Method.—The clinical method of attack readily lends itself to the study of patients who have pulpless teeth and who may or may not be suffering from some pathologic disturbance which is thought to be related to a focus of infection. When these observations were first made, there were many papers and case reports setting forth a long list of disease that were due to oral infection and stating how rapidly the patient improved after the eradication of certain pulpless teeth, especially those that showed radiolucent areas surrounding the root ends. There is no doubt that certain cases of arthritis, recurrent acute iritis, neuritis, etc., have been permanantly cured by the extraction of diseased teeth. In a recent contribution, Ernest E. Irons[1] states that 20 per cent of cases of recurrent acute iritis seem traceable to closed periapical lesions. It is of great importance to note that in this article, Dr. Irons states:

It has been assumed by physicians that if some cases of arthritis can be cured by the discovery and removal of peridental disease, most cases af arthritis can be thus treated successfully. The result has been the abuse of the theory of focal infection and the loss by many patients of serviceable and innocuous teeth.

Very justly, he suggests that many dentists have shown "too great a willingness to cooperate, and in some cases, sound teeth which were so unfortunate as to develop insensitive pulps have had their masticatory service terminated."

In several scholarly addresses before the Chicago Dental Society and the Illinois State Dental Society, Joseph L. Miller[2] has pointed out the fallacy of condemning all pulpless teeth. He has repeatedly suggested that we must know the course of untreated disease before we can draw correct conclusions concerning the effectiveness of our treatment. It was Claude Bernard[3] who said, "We cannot judge the influence of a remedy on the course and outcome of disease if we do not previously know the natural course and outcome of the disease." As a general rule, physicians are not so willing to place the cause of many chronic ailments at the threshold of pulpless teeth at the present time as they were a few years past. There are a few who still insist on the extraction of all pulpless teeth. Undoubtedly, they have been influenced by overenthusiastic statements of certain workers. It is a very common mistake of many physicians and also of certain dentists to attempt to determine the part the oral cavity plays in systemic disease by the study of dental roentgenograms. If a pulpless tooth happens to be present, they imme-

1. Irons, E. E.: Dental and Medical Practice, J.A.D.A., 21:1986 (Nov.) 1934.

2. Miller, J. L.: Dental Infection as Cause of Systemic Disease, J.A.D.A., 17:1598 (Sept.) 1930.

3. Bernard, Claude: Introduction to Study of Experimental Medicine, New York: The Macmillan Company, 1927, p. 194.

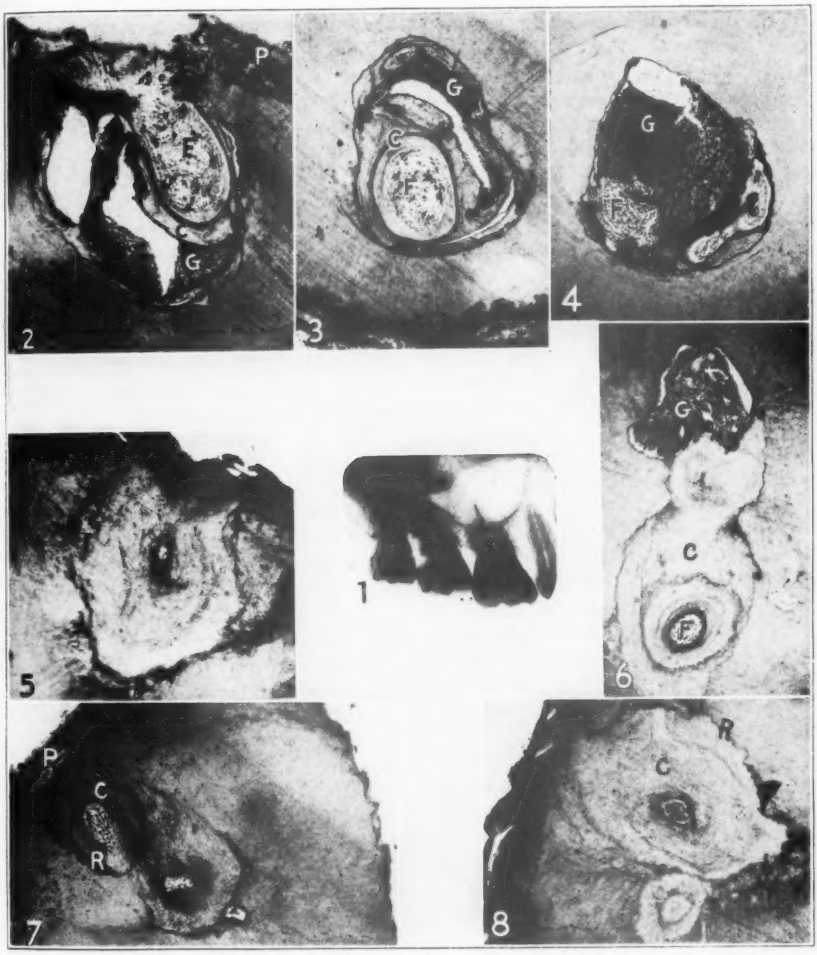

Fig. 1.—*2-4,* lingual root; *5-8,* buccal roots. *1,* roentgenographic film sixteen years after roots were filled. The root ends are normal. *2,* cross-section of lingual root through apical foramen: *P,* periodontal membrane; *F,* fibrous tissue separated from guttapercha filling material *(G)* by a layer of calcified material *C. 3,* guttapercha, *G,* surrounded by calcified tissue, *C,* and remaining fibrous tissue in lumen of canal *F,* which is entirely free from inflammation. *4,* guttapercha *G,* fibrous tissue *F. 5,* mesiobuccal root end with very minute lumen of canal. *6,* mesiobuccal root at level of root filling. This root had two canals. One which was opened contains guttapercha *(G)* and operative débris, the other, very much reduced in size, contains fibrous tissue *F.* Extensive repair calcification is seen at *C. 7,* distobuccal root end: Periodontal membrane *P,* and calcification within the canal at *C;* resorption on buccal surface of root *R. 8,* distal root at level slightly removed from foramen; resorption within canal, *R,* and repair calcification, *C.*

diately place full responsibility on this tooth, entirely overlooking the fact that the real seat of the trouble may be some degenerating or inflamed pulp. Such conditions are much more likely to be the source of metastatic lesions than are the well encapsulated areas of granulation tissue of apical regions. Pulps undergoing degeneration may be found in teeth that have never been attacked by caries as well as beneath inlays or fillings of various sizes. To isolate such diseased pulps requires a careful study of every tooth in the mouth by a competent dentist. Today, it is not sufficient to glance at the roentgenograms and say that the teeth are in either a satisfactory or an unsatisfactory condition. Again, when the clinical and laboratory findings do not agree, we must always accept the clinical.

Many practitioners who are especially interested in pulp canal therapy have observed their cases both clinically and roentgenographically over a period of years. This was done as a means of determining the success of their treatments. While all workers are not agreed as to the value of negative roentgenographic evidence, this method has been of service. It is always well for the clinician to study the results of treatment. Clinical studies in this manner have been valuable in placing modern pulp canal therapy on the higher plane where it is found today.

Bacteriologic Method.—The science of bacteriology has played an important rôle in the study of the pulpless tooth, although from this group of investigators we have received the most discouraging reports. It is toward this method of study that I would like to direct attention. It is obvious from a study of these reports that little or no attention has been paid to the manner in which the tooth was treated or the length of time that has elapsed since the pulp was removed. There has been a failure to recognize that pulp canal therapy has been passing through a radical change and that root canal therapy in general cannot be condemned on evidence gathered from cases improperly treated. In support of this statement, I quote the following from the conclusions in a paper published under the names of well-known physicians.[4]

> That a high percentage of pulpless teeth eventually show roentgen-ray evidence of bone change at the apex even though there is no evidence of bone destruction at the time the root canals are filled seems a fair assumption . . . it seems justifiable to regard all pulpless teeth as probable foci of infection whether they show apical changes in the roentgenograms or not.

We have in our files records of many thousands of cases, some of which go back to 1918. All of these cases were treated with as strict a regard for asepsis as is possible in a college clinic, and I am happy to say that a high percentage of these *do not show* such degenerations. I have had the opportunity of studying histologically some of these teeth that were removed for one cause or another years after treatment, and I shall have more to say concerning this a little later. Rhoads and Dick[4] have attempted to show that the root ends of roentgenographically negative pulpless teeth harbor many more organisms than the root ends of teeth containing vital pulps. In spite of the great amount of painstaking work that their study represents, there are important records that are missing. They have apparently failed to recognize that it is impossible to extract a tooth without contamination of the root end. The very movements that are necessary to remove a tooth from its socket favor the carrying of bacteria from the gingival crevice or pocket toward the root end. In the

4. Rhoads, P. S., and Dick, G. F.: Roentgenographically Negative Pulpless Teeth as Foci of Infection: Results of Quantitative Cultures, J.A.D.A., 19:1884 (Nov.) 1932.

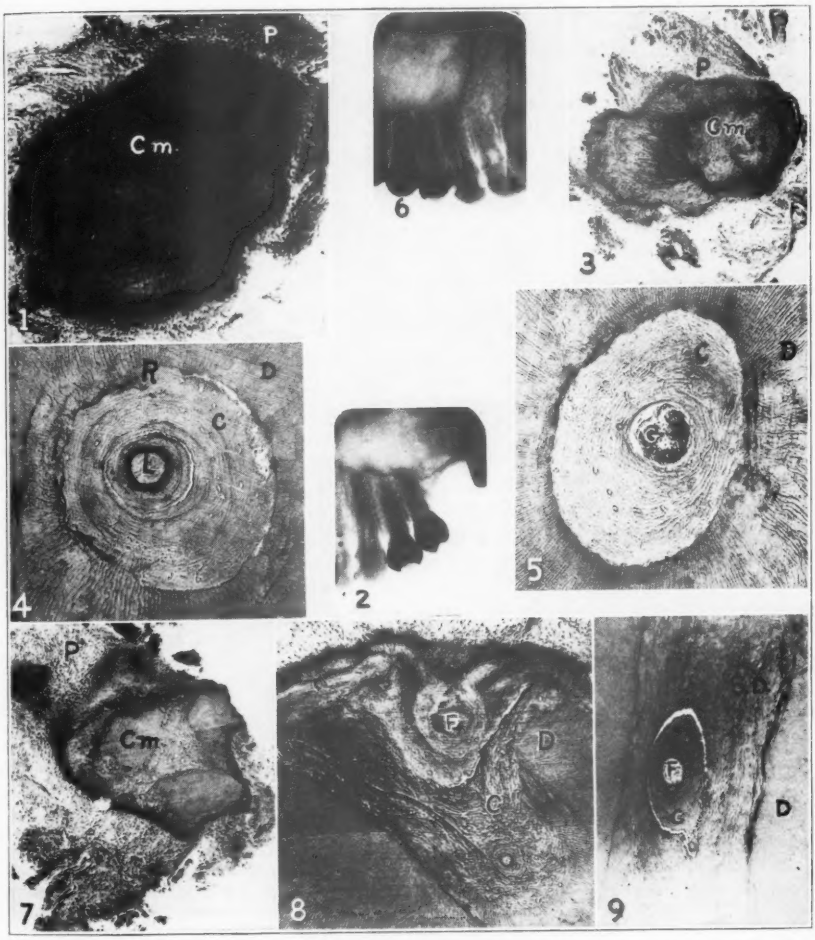

Fig. 2.—*1-5*, upper right first bicuspids, which contained an incomplete root filling for over twenty years. *1*, cross-section of buccal root with surrounding periodontal membrane: *Cm*, cementum; *P*, periodontal membrane. *2*, roentgenographic film taken short while before extraction. The root end appears normal and a canal cannot be seen between the root filling and the root apex. *3*, cross-section of lingual root end: *Cm*, cementum; *P*, periodontal membrane. *4*, cross-section short distance from root end; irregular resorption *R;* repair calcification *C;* lumen of canal completely closed by a homogeneous calcification, *L;* dentin, *D. 5*, filling material, *G;* calcified material, *C;* dentin, *D. 6-9*, upper right lateral incisors. *6*, roentgenographic film taken before extraction and nineteen years after operator unsuccessfully attempted to find root canal. *7*, cross-section of apex: Cementum, *Cm;* periodontal membrane, *P. 8*, section through remains of apical foramen: Dentin, *D;* extensive deposit of cementum-like material in canal, *C;* two small canals containing fibrous tissue and small capillary, *F;* periodontal membrane, *P. 9*, cross-section in midroot: Primary dentin, *D;* secondary dentin, *S.D.;* cementum-like deposit, *C;* fibrous tissue in lumen, *F*.

clinical description of their cases, they have failed to state the condition of the investing tissues or the depth of periodontal pockets. It is also interesting to note that twenty-six buccal teeth and three anterior teeth were used in the study of root ends of pulpless teeth; whereas, of the control teeth having vital pulps, five were from the buccal and nine from the anterior segment. It is a well-known fact that periodontal pockets are found more frequently in the buccal segment, also that buccal teeth as a rule require a greater movement to effect a release and therefore provide greater opportunity for contamination. Bernier[5] has made a careful study of the bacteriology of root ends both before and after removal of the tooth. He found that whenever an entrance to the root end was gained by using a trocar and cannula, a negative culture was obtained in 76 per cent of cases; and that when the same teeth were extracted, every possible means being used to prevent apical contamination, positive cultures were obtained in 92 per cent. In this work, every tooth studied was from the anterior segment of the maxilla, the area that offers the least difficulty in packing, sterilizing and extracting.

Histopathologic Method.—The histopathologic method of studying the condition of the tissue within the apical canals, the periapical structures and the apical cementum, while more time consuming and laborious, seems to be the most reliable. If these structures are free from all evidence of inflammatory reaction, we are certain that pathogenic organisms have not established themselves in these tissues. Kolmer has defined infection as the successful invasion and growth of micro-organisms in the tissues of the body. He states that organisms merely invading the tissues are quickly destroyed and are not able to proliferate. Many workers[6] have repeatedly shown that the reactions that occur in the apical canals and periapical tissue after pulp removal are definite, and that it is not unusual, in cases of negative roentgenographic evidence, to find these structures in a healthy condition and free from all indications of infection.

In support of these statements, I present photomicrographs of a few cases with definite clinical histories. Figure 1 shows an upper first molar from my own mouth, a tooth that was rendered pulpless in 1917, and was extracted in 1933 because of fracture on the crown that involved the bifurcation. Frequent roentgenographic examination throughout this period failed to reveal pathologic disturbance. Views *2, 3* and *4* are of the lingual root, *2* showing the foramen and periodontal membrane, the root filling being separated from the remaining fibrous tissue by a calcified material. Views *3* and *4* are slightly removed from the foramen; *5* and *6* are of the mesiobuccal root; *6* shows two canals in the root, which were demonstrated clinically at the time of treatment, but only one of which was filled to the vicinity of the root end, and

5. Bernier, J. L.: J. D. Res., to be published.

6. Blayney, J. R.: Biologic Aspect of Root Canal Therapy, D. Items Int., 49:681 (Sept.) 1927; Problem of Pulpless Tooth as Seen by Clinical and Laboratory Investigation, J. D. Res., 10:425 (Aug.) 1930; Tissue Reaction in Apical Region to Known Types of Treatment, ibid., 9:221 (April) 1929; Present Conception of Vital Reactions Which Occur Within Apical Tissues After Pulp Removal, J.A.D.A., 16:851 (May) 1929. Coolidge, E. D.: Pulp Pathology and Treatment Problems, J.A.D.A., 15:1623 (Sept.) 1928. Hatton, E. H.: Bacterial and Histologic Findings After Present Day Root Canal Treatment, D. Cosmos, 70:924 (Sept.) 1928; Histopathology of Apical Region of Teeth with Partly Filled Root Canals, J.A.M.A., 77:1805 (Dec. 3) 1921; Regeneration of Apical Region After Treatment and Filling of Pulp Canals, J.A.D.A., 13:485 (April) 1926.

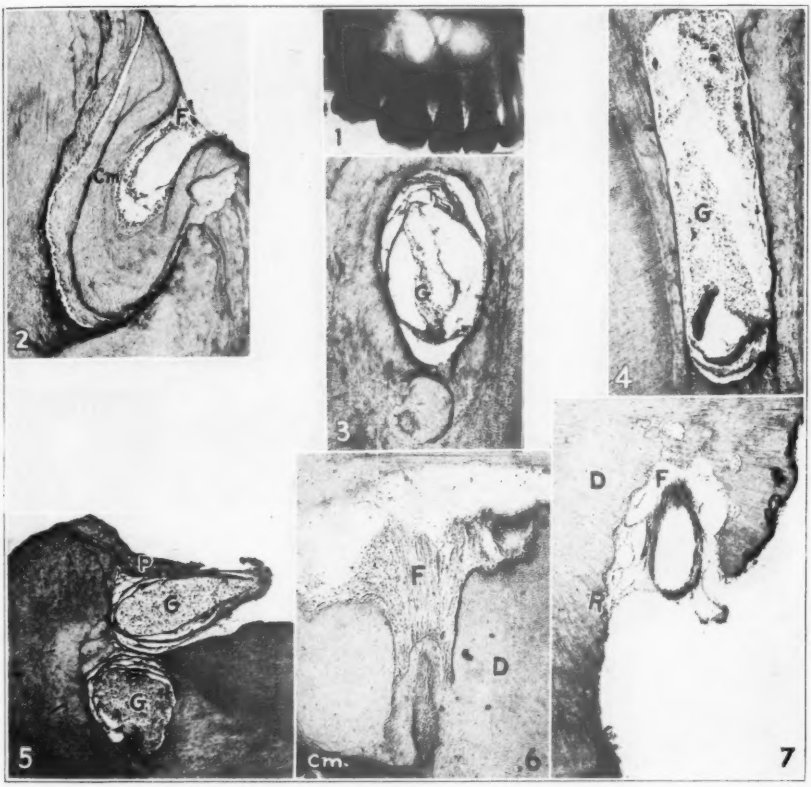

Fig. 3.—*1,* roentgenographic film just prior to extraction and fourteen years after pulp removal. *2,* apical foramen of lingual root containing fibrous tissue, *F;* extensive deposit of cementum about periphery of foramen, *Cm. 3,* guttapercha, *G,* surrounded by shrunken fibrous tissue, *F. 4,* canal filled with guttapercha, *G. 5,* cross-section of distobuccal root: Foramen filled with guttapercha, *G,* which is surrounded by periodontal membrane, *P. 6,* fibrous tissue, *F,* in apical canal of mesiobuccal root; dentin, *D;* cementum, *Cm. 7,* buccal surface of mesial root; dentin, *D;* area of resorption, *R,* which is filled with fibrous tissue, *F.*

7 and *8* show the healthy fibrous tissue in the apical portion of the distal root.

Figure 2, *1* to *5,* shows an upper bicuspid with a partially filled canal from a member of my immediate family. A vital pulp was removed from this tooth prior to 1914 and the tooth was not extracted until 1934 owing to fracture of the buccal plate, which involved a considerable portion of the root. Views *1* and *3* show the apical cementum with the surrounding periodontal membrane free from inflammation; *4* shows extensive calcification in the canal, which has completely obliterated all traces of soft tissue; *5* shows the filling material with some operative débris completely surrounded by cementum-like material, and *6* shows

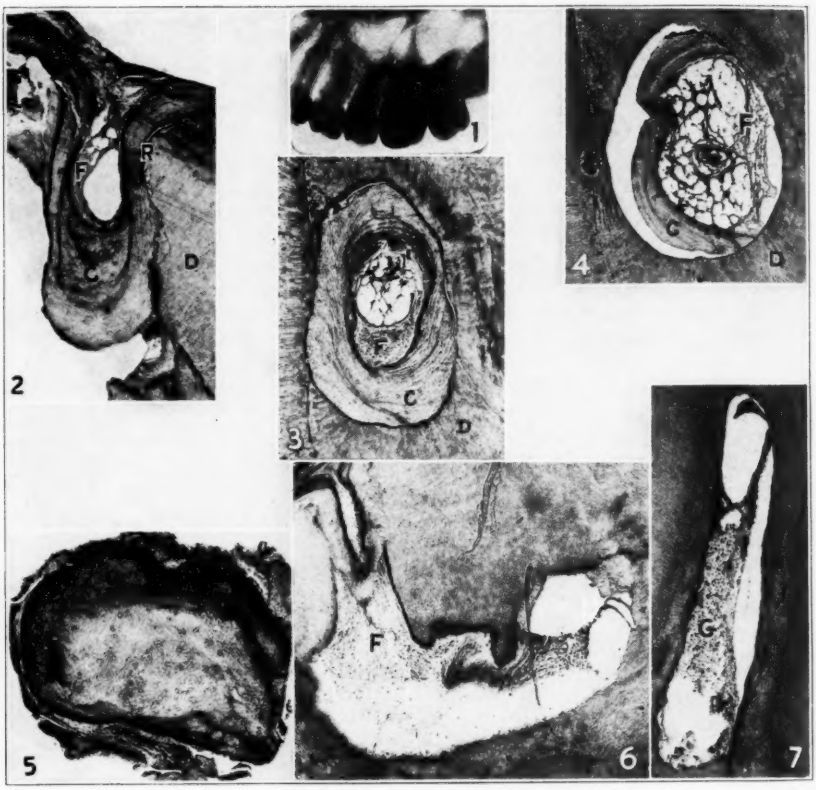

Fig. 4.—*1,* roentgenogram of upper first molar showing condition at time of extraction; root filling placed twenty years before. *2,* section through apical foramen of lingual root: Periodontal membrane, *P;* line to which resorption progressed following treatment, *R;* fibrous tissue in canal, *F;* dentin, *D;* repair calcification continuous with cementum, *C. 3,* cross-section through lingual canal short distance from root end; Dentin, *D;* repair calcification, *C;* fibrous tissue in canal, *F. 4,* cross-section of lingual canal near level of root filling: Dentin, *D;* repair calcification, *C;* fibroid tissue, *F. 5,* cross-section of mesiobuccal root surrounded by periodontal membrane. *6,* fibrous tissue, *F,* in canal near foramen of mesiobuccal root. *7,* guttapercha, *G,* in mesiobuccal root.

the upper left lateral incisor from the same patient. In 1915, I found that the pulp of his tooth did not respond to a clinical test for vitality. Careful and repeated exploration failed to reveal either a pulp or a pulp canal. The crown of the tooth was filled without mechanical opening of the root for fear of perforation or destruction of tissue with caustics. This tooth was extracted in 1934 because of the fractured crown. Views *7, 8* and *9* show the apical cementum and periodontal membrane, the apical foramen with two minute canals and the remains

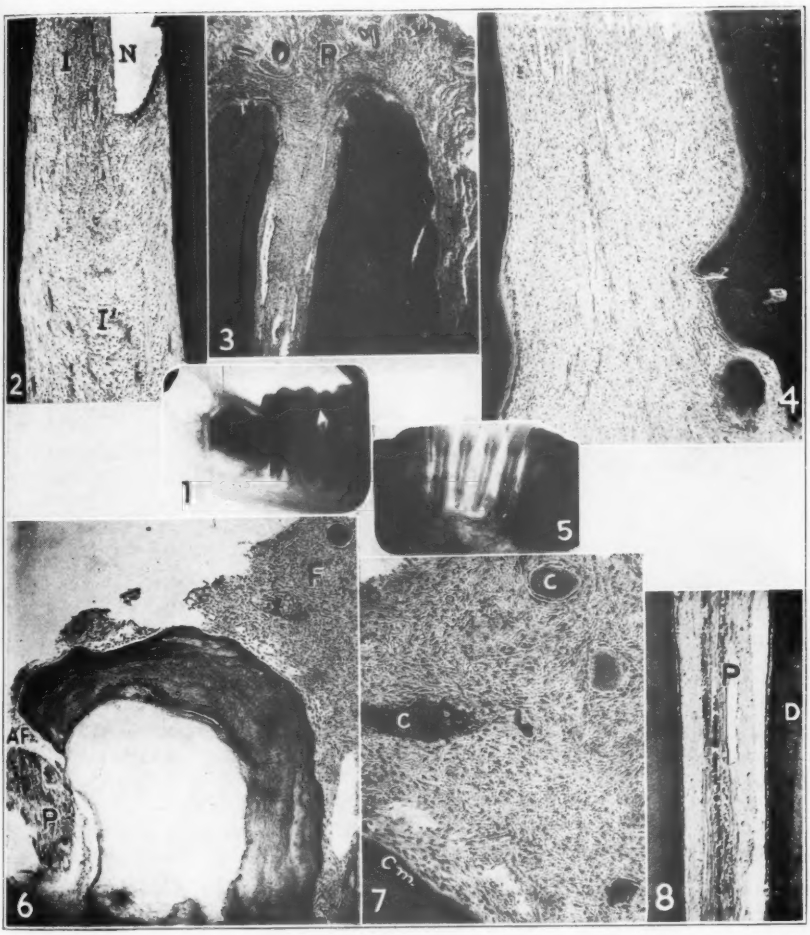

Fig. 5.—*1,* roentgenogram of carious lower first molar from patient 8½ years old. Areas surrounding mesial and distal roots are to be noted. *2,* longitudinal section of mesiobuccal canal near pulp chamber: Area in which pulp tissue is entirely destroyed, *N,* surrounded by inflammatory zone, *I,* with only slight amount of inflammatory reaction, *I'*. *3,* longitudinal section of distal root through apical foramen: Surrounding periapical membrane, *P.* There is an absence of inflammatory reaction. *4,* longitudinal section of mesial root in apical region. There is a complete absence of inflammatory reaction. *5,* roentgenogram of lower incisor with radiolucent area about apex. *6,* longitudinal section of root: Apical foramen with healthy tissue, *A. F.;* mass of fibrotic tissue, *F,* which has replaced periodontal membrane and was responsible for roentgenographic findings; pulp tissue, *P. 7,* higher power of fibrotic mass seen in *6:* Areas of calcification, *C;* cementum, *Cm.* There is an absence of inflammatory reaction. *8,* longitudinal section in midroot: Normal pulp, *P;* dentin, *D.*

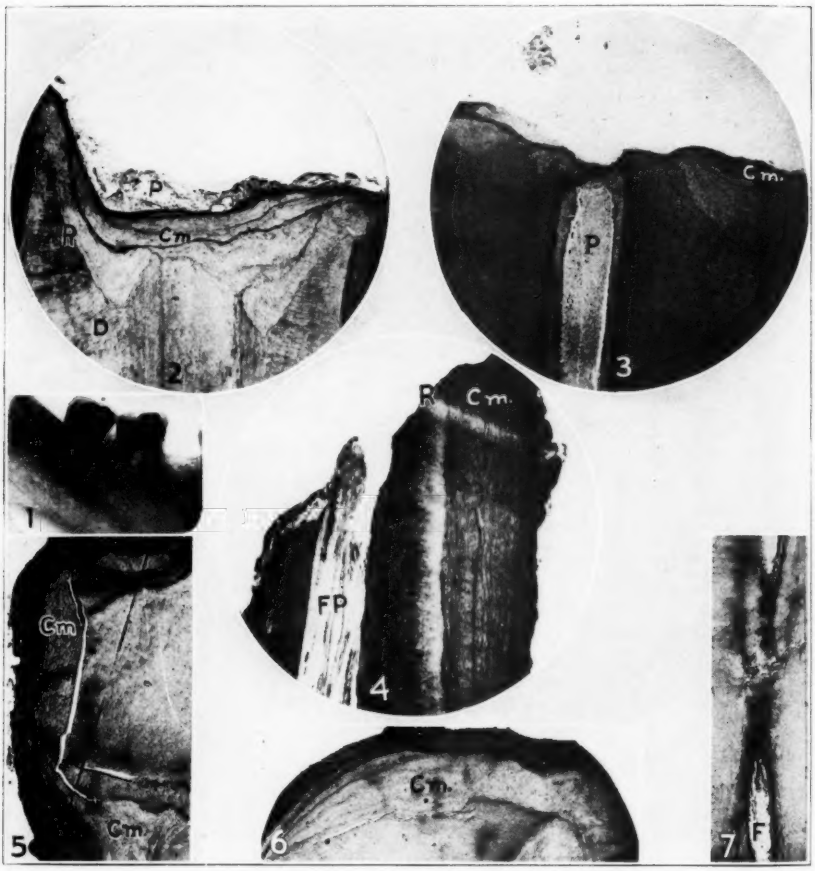

Fig. 6.—*1*, roentgenogram of lower first molar showing short mesiobuccal root. *2*, longitudinal section of mesiobuccal root laterad from pulp canal: Dentin, *D;* line to which resorption progressed after injury, *R;* cementum, *Cm;* periodontal membrane, *P. 3*, same as *2*, but passing through pulp canal: Normal pulp, *P;* cementum, *Cm. 4*, longitudinal section of distal root: Marked resorption of root end, *R;* fibrotic pulp, *F. P.;* cementum, *Cm. 5-7*, root fragments remaining in jaw for years after extraction: Cementum built across fractured dentinal surface, *Cm* (*5* and *6*) and fibrous tissue remaining in canal *F* (*7*).

of the canal in the midroot. In spite of the fact that these roots did not contain perfect root fillings and that the lateral incisor showed a shortened root, none of the microscopic sections suggest the slightest possibility of an inflammatory reaction. The patient has enjoyed good health throughout this time, except for the fact that very suddenly and for no apparent cause, a retinal hemorrhage caused the loss of sight in the right eye in 1926. A thorough study of the

case failed to reveal a condition that would explain the trouble. These and other pulpless teeth that were clinically and roentgenographically negative were retained. Under active treatment for eight months, the vision slowly improved and has been normal since 1928. It is quite evident that the two teeth recently studied had no relation to the eye condition.

Figures 3 and 4 are from the upper left and right first molars, which had been pulpless for fourteen and twenty years, respectively. The patient, in middle life, complained of arthritis in the shoulder. Clinical and roentgenographic examination taken over a period of years repeatedly showed the root ends to be normal, although the root canals were underfilled. The physician in charge of the case asked the patient to consult the dentist and have both molars extracted. This the dentist refused to do on the grounds that sufficient evidence was not available to warrant the loss of such important teeth. The physican insisted that the teeth be removed and referred the patient to another dentist, who extracted the teeth. I obtained both specimens a few hours after extraction. Figure 3, *2, 3* and *4*, shows the sections of the lingual root. View *5* is through the foramen of the distobuccal root, which contains guttapercha surrounded by the foramen of the distobuccal root, which contains guttapercha surrounded by fibrous tissue. View *6* shows the fibrous tissue in the apical canal of the mesiobuccal root and *7* shows an interesting area of resorption on the lateral surface of the buccal root, which is not connected with the pulp canal. Figure 4 shows quite the same reaction in all canals as is seen in the preceding case, with the possible exception that the filling in the lingual canal is somewhat shorter. Here, we find that the lingual canal, *2, 3* and *4*, contains a considerable amount of fibrous tissue. There is nothing seen in the sections of either of these cases to suggest that the canals were harboring pathogenic bacteria. The patient has been hospitalized with rest and the best care and yet the arthritis persists after removal of the teeth. It is undoubtedly such cases that have caused Dr. Irons to state that some physicians and dentists are too willing to remove teeth in an effort to relieve arthritis.

Figure 5, *1*, presents a roentgenogram of a carious lower first permanent molar from a young patient. There is a marked area surrounding the distal root, also a smaller area around the mesial root. View *2* shows the area of destruction and inflammation of the pulp in the gingival portion of the mesial root; *4* shows a moderately high power of the pulp tissue in the apical foramen, and *3* shows the pulp and periapical tissue of the distal root. The pulp tissue in the apical region does not show the slightest signs of inflammation or degeneration.

In the next case, that of a woman, aged 50, who has been suffering from chronic arthritis, the physician in charge finally ordered full mouth roentgenograms, which revealed the condition surrounding the lower central incisor shown in *5*. The patient was referred to her dentist for an extraction. On clinical examination, as this tooth was found to be normal in all respects, the dentist refused to operate. Six months later, the patient returned to the physician, still complaining of arthritis. The physician inquired concerning the removal of the lower front tooth, and when told that the tooth had not been extracted because all clinical tests were satisfactory, he flatly refused to have anything to do with the patient until his orders were carried out. The patient did not wish to change physicians as she had been under the care of this one for several years; con-

sequently, she consented to have the tooth removed. In *6*, the apical region with the apical foramen on the left and the mass fibrous tissue on the right is shown; in *7*, a higher power photomicrograph of this fibrous tissue, with several areas of calcification, is shown and in *8*, a longitudinal section of the pulp; all of which are free from any sign of degeneration or inflammation. This is a case of periapical osteofibrosis,[7] a condition that cannot be diagnosed from the roentgenograms alone. Needless to say, the removal of the tooth did not change the arthritic condition.

Judging by their writings, certain physicians look askance on teeth with roots presenting roentgenographic evidence of resorption or at root fragments often found in the jaw years after extraction, even though the roentgenogram reveals no bone change. Figure 6, view *1*, shows a lower first molar with a very short mesiobuccal root and a blunt end on the distal root. The patient stated that, years before, an impacted bicuspid was removed from the jaw, and at the time of operation, the dentist cut off the root of the molar. Apparently, complete healing had taken place, at least as far as the clinical and roentgenographic evidence was concerned. In *2*, the repaired end of this root is seen; in *3*, a longitudinal section showing the repair and the dental pulp free from inflammation, and in *4*, a longitudinal section of the distal root, showing the pulp somewhat fibrotic, but free from inflammation, and a considerable resorption of the root end.

Views *5*, *6* and *7* are of sections prepared from a root fragment removed from the maxilla years after the tooth was extracted. A rather thick layer of cementum is deposited over the fractured dentinal surface in *5* and *6*, and in *7*, the remaining atrophic dental pulp tissue, which is free from inflammatory changes, is seen. Such conditions have been reported several times in the literature.[8]

7. Stafne, E. C.: Periapical Osteofibrosis and Cementoma, J.A.D.A., 21:1822 (Oct.) 1934.

CONCLUSIONS

During the past twenty years, much has been learned concerning the pulpless tooth. We now know that a tooth with a vital pulp is much to be preferred.

If pulps are removed from teeth under an aseptic technic and the remaining tissue is not injured with caustic drugs, we may expect to have a satisfactory percentage of success.

It is quite possible that a tooth containing a vital pulp, which, upon an indifferent clinical examination, looks satisfactory, and is negative in the roentgenogram, may contain a vital degenerating pulp capable of disseminating pathogenic organisms.

Many carelessly managed pulpless teeth are a menace to health, but the findings of a pulpless tooth in the mouth of a patient who complains of systemic disease is not *prima facie* evidence that the tooth is the causative factor.

In certain areas, it is difficult to obtain dental roentgenograms that sharply define the apices of all roots. In some instances, pathologic changes at root ends are not revealed by roentgenograms. This does not mean that because a tooth contains a root filling and the roentgenographic evidence is negative, it should be extracted.

We have evidence, even in some cases of positive roentgenographic findings, that the changes are not of a degenerative or inflammatory nature associated with death of the pulp and that the removal of

8. Thomas, N. G.: Studies in Protective Cementum Development, D. Cosmos, 64:385-395 (April) 1922. Fletcher, M. H.: Repair on Cementum, J.A.M.A., 56:109-111, 1911.

such teeth can in no wise benefit the patient who suffers from chronic arthritis or similar conditions.

The bacteriologic study of root ends wherein the inoculum is obtained after extraction is very misleading. For a reliable study, the material must be gathered before the root is disturbed.

Roentgenographic findings of root resorption in the absence of bony changes are not sufficient evidence to justify the extraction of the teeth so involved.

It would be much better for physicians to accept the findings of their dental consultants rather than to demand the removal of teeth which every evidence possible to obtain suggests are innocuous.

STABILIZATION OF PARTIAL DENTURES*

By DAVID W. McLEAN, D.D.S., Los Angeles, Calif.

DENTAL periodical literature indicates wide divergence of opinion regarding the usefulness of partial dentures. While certain writers consider the appliance, supported partly by natural teeth and partly by the mucosa, to be a reasonably permanent device, others seemingly consider it a mere buffer to prepare the patient for the wearing of full dentures at an early date.

That the combination of a successful partial denture and a complement of natural teeth is more efficient from a functional standpoint than is a full denture seems to be accepted. The controversy centers around the frequent failure of the partial denture and its destructiveness as regards the ridge and abutment teeth; in other words, around the problem of its stabilization.

The partial denture, being partly tissue-borne, must rock under chewing stress upon its cushion of mucosa. Anchored rigidly to several or all of the remaining teeth, it will rock just the same; it will simply take longer to do so, because it will have more teeth to rock loose, before it itself can rock.[1]

It is not surprising then, that writers primarily sympathetic to the abutment teeth should favor ridge support of the partial denture, while others prefer rigid attachment to as many natural teeth as possible, sparing the ridge against the day of full dentures. It is only as we can reconcile the two points of view by stress equalization that the partial denture can take its rightful place in dental practice.

The partial denture stage of the patient's life history is marked by the sad fruition of previous errors and neglect. There are fewer teeth left to do the work of mastication and these few, dulled by wear and perhaps by the flatness and deformities of bad dental work, not only have more work of their own to do, but must, in addition, give support to prostheses replacing their lost neighbors; and this at a time when the periodontium lacks the vigor of former years. The pa-

*Read before the Section on Partial Denture Prosthesis at the Seventy-Sixth Annual Session of the American Dental Association, St. Paul, Minn., Aug. 9, 1934.

1. Little, A. P.: Partial Denture Construction from Engineering Point of View, Based upon Physiologic Requirements, J.A.D.A., 15:69 (Jan.) 1928.

tient now, more than ever before, needs an efficient masticating apparatus; and plainly it becomes the duty of the dentist to wrestle with the problem of the partial denture, and conquer it.

That problem is basically one of stabilization; and, fundamentally, it divides into two parts: (1) to minimize the rocking of the appliance upon the mucosa, and (2) to reduce the torque of the moving appliance to a point within the margin of safety of the abutment periodontium.

FACTORS IN THE STABILIZATION OF PARTIAL DENTURES

The factors which enter into the solution of these two basic problems of stabilization may be grouped under several

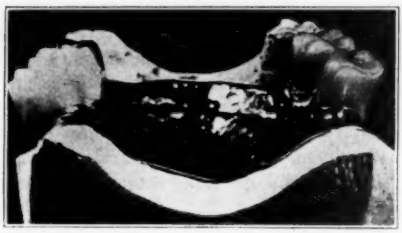

Fig. 1.—Supplied teeth supported upon edentulous ridge, the occlusal surfaces extending so far buccally that excessive leverage upon ridge and abutments results.

headings: the reduction of mucosa resilience; the design of saddles and connectors; the position and arrangement of the supplied teeth; occlusal coordination, and attachments to the remaining teeth.

Reduction of Mucosa Resiliency.—Obviously, the presence of an excessive amount of soft tissue covering the ridge which must support a denture saddle means excessive movement of the appliance under masticatory stress. Movable soft tissue is piled up along the tops of many edentulous ridges, and such ridges are greatly improved for either saddle support or the use of fixed bridge pontics, by recourse to very simple surgical procedures.

A few drops of procaine by infiltration will prepare the field. One end of the strip of tissue is grasped in tissue pliers and with a small curved lance, the entire strip is sliced off to give the remaining tissue a well-rounded contour. The corresponding area in the temporary denture is covered with palliative dressing, and the appliance is bitten to place in the mouth, and worn with surprisingly little discomfort during healing.

Other means of reducing tissue resilience concern themselves with actual precompression of the soft tissues. The first means is a preliminary denture, which

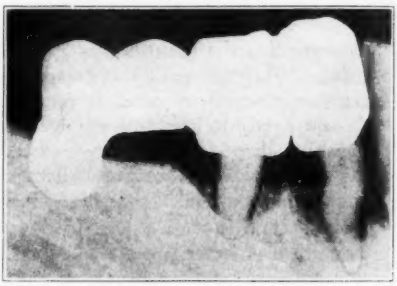

Fig. 2.—Fixed bridge illustrating strikingly paradental effect of leverage transmitted to abutment teeth through rigidly attached appliance.

should be worn for several weeks before impressions are made for the appliance proper. Otherwise, the mucosa will pack down rapidly under the "permanent" appliance, which will soon require rebasing —not a simple procedure if the bases are of metal.

The second means of securing precompression of the mucosa lies in the impression technic. Several methods have been suggested, such as the modeling compound impression with a wash of plaster of Paris or colloid. To this, the objection is that

the wash is not sufficiently sluggish or resistant, and the confining pressure not sufficiently definite. Another suggestion is the modeling compound impression, with the teeth cut out and the spaces filled with colloid for reinsertion under pressure. There is no guide to the accurate replacement of such an impression in the mouth for completion. When finished, it may present a good impression of the ridge and of the natural teeth, but in wrong relationship to each other. The end-result will be a saddle which, because misplaced, lacks adaptation to the tissues.

The Wadsworth modeling compound technic provides very definite tissue compression. A snap impression of compound or colloid is taken and poured in plaster or stone. A tray design is outlined on the model to include areas permitting vertical withdrawal. Other areas will be taken as secondary sections and withdrawn laterally. The teeth on this model are covered with three layers of No. 60 tinfoil, loosely laid on. Vulcanite rubber, reinforced with wire, is then cemented to the model as outlined, with rubber cement, and built up to biteblock form. The model is then dropped into a flask and vulcanized, after which the tray is trimmed for muscle clearance. On removal of the tinfoil, the tray clears the teeth and rides upon the soft tissues.

The vulcanite tray is then adjusted to the occlusion, and opposition in the other jaw is provided if lacking, by means of biteblocks. Modeling compound, softened by dry heat in the Wadsworth modeling compound heater, is then spread over the tray, and the impression is taken under biting pressure. The periphery is muscle trimmed. Where the soft compound is pressed out of the tray along the labial and buccal surfaces of the remaining teeth, it is trimmed away, in the mouth, with a lance, and those surfaces are completed with secondary sections.

Fig. 3.—Cast duralumin teeth set in vulcanite model with velum ridges, gums and sockets. A bar is extended distally from an "open clasp" (a unit clasp patterned after the design of the Roach bar clasp). The contact between the abutment tooth and its mesial neighbor may be noted.

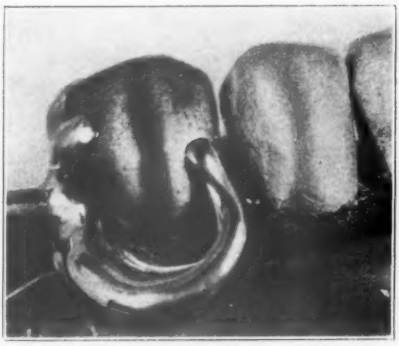

Fig. 4.—Abutment tooth moved distally in velum socket by downward pressure on bar extension. The space between the abutment tooth and its mesial neighbor may be noted.

This technic produces rather severe compression and, in some cases, the "coralite" impression material of Humphreys[2] may be used to good advantage in

2. Humphreys, K. J.: Bull. So. California D. Soc., 1:21 (Feb.) 1934.

a similar tray or in one of hard baseplate material, well reinforced with wire.

Saddle Design.—Partial denture saddles function upon the principle of snowshoes. Where the ordinary shoe will sink into soft snow, the load the snow will bear increases with the size of the snowshoe. Large saddles, therefore, taking advantage of all possible ridge support, are indicated for partial dentures. Palatal connectors should be broad and flat, with relief for hard median line areas.

Tooth Position and Arrangement.—It is axiomatic that supplied teeth should be supported upon the ridge. Often, the upper ridge lies well inside of the lower one, and teeth set to normal occlusal relationship with their opponents will have occlusal surfaces lying well beyond the ridge, and the resulting leverage on the appliance will destroy the bone under the saddles and around the abutment teeth, just as it probably destroyed that about the teeth already lost.

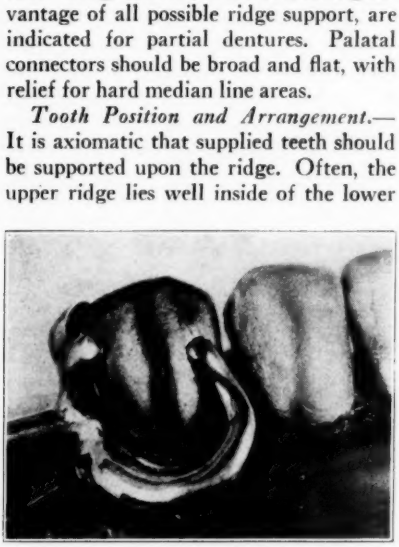

Fig. 5.—Increased pressure overcoming resilience of clasp arm. The arm bends and the clasp moves upon the abutment tooth. The changed position of the occlusal rest may be noted. The space between the two teeth shows that the tooth still occupies a distal position in its socket.

Not only should the teeth be supported upon the ridge, but also their axial line should lie as nearly as possible in the line of vertical stress. It is frequently advisable to "cross the bite," as cuspal coordination can be developed quite satisfactorily when the buccal cusps of upper molars rest in the fossae of the lower ones.

Occlusal Coordination.—The periodical literature indicates an increasing realization of the importance of smooth and efficient cooperation of the teeth during chewing motions, but not a few men still advocate developing the occlusal surfaces of partial dentures in such a way that the stress load falls mostly upon the natural teeth, and diminishes progressively toward the free end of the appliance. Such a policy accepts too low a standard of functional efficiency for the appliance.

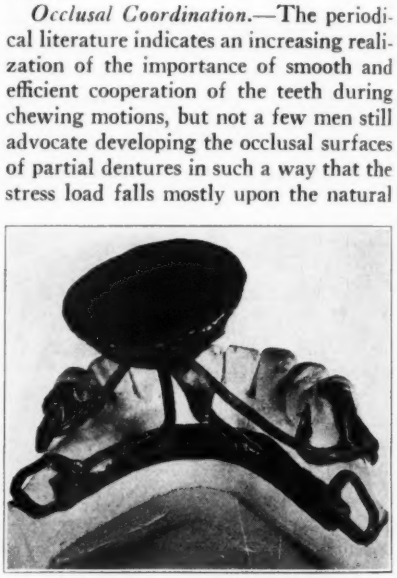

Fig. 6.—Two open clasps with distal extension bars and lingual bar with loops for anchorage in plastic base. All metal parts of the partial denture are waxed upon a model of casting investment, sprued to the same button and cast in one operation. The author regards this procedure with subsequent assembling of the parts, as definitely preferable to the one-piece casting.

With adequate mucosa support and suitable equalization of stress between ridge and abutments, the partial denture can, and should, play a full part in the chewing function.

Real occlusal coordination cannot be developed in a partial denture that functions against worn-out, deformed or misplaced teeth in the opposite arch. Orton early called attention to the necessity for reshaping abutment teeth of bridges[3]; but, in practice, it is still almost universally overlooked.

Too often, the literature advises us to first rebuild the remaining natural teeth to "restore balance" and then to proceed with the partial denture.

Any one who has set up artificial teeth on an articulator knows that he cannot make porcelain teeth function against flat, misshapen or misplaced teeth in the other arch. He must grind the opposing teeth or move them about to gain altered position, length and angulation of cusps, to coordinate them with their opponents.

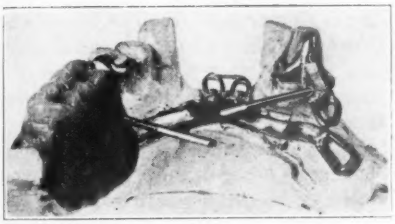

Fig. 7.—Open clasp with distal extension assembly attached to lower right cuspid, ready for waxing. On the left side, a cast circular or Nesbett clasp is in place and the distal extension assembly and denture unit are waxed ready for flasking.

It is also impossible to rebuild natural teeth in the mouth to coordinate properly with misshapen or misplaced opposing teeth. To make any real functional change in the occlusal surfaces, all of them, natural and artificial and in both arches, must be developed simultaneously by reciprocal adaptation on an articulator adjusted to reproduce the jaw movements.[4]

Attachments.—Attachments for partial dentures are usually classed as "direct" when they attach directly to the abutment teeth, and "indirect" when they rest for support on some distant natural tooth. Indirect attachments are not truly attachments, but should be called auxiliary stabilizers.

Auxiliary stabilizers: Early partial dentures provided full palatal coverage in the upper jaw, and full lingual gum coverage in lower bilateral cases. The early gold or vulcanite plate was trimmed to rest against the remaining natural teeth, and thus obtained full auxiliary stabilization, such as we still have in the continuous lingual clasp of J. Wright Beach[5] and of Woodworth.[6]

When the continuous lingual clasp is attached to the denture proper, as part of a rigid attachment to the natural teeth, it adds little to the immobilizing of the denture, and exerts vicious stress on the steep inclined planes on which it rests.

It is occasionally a valuable adjunct when attached to the abutment clasps themselves, to unify the natural tooth support; but stressbreakers of some kind are indicated between the clasp assembly and the denture.

Many, in fact far too many, modern dentures have long arms that reach out to rest on cuspids or central or even lateral incisors, for fractional auxiliary stabilization against the lift of sticky food, or the sagging of the upper denture under the pull of gravity. In the lower jaw, gravity works with, rather than against, the appliance, and auxiliary sta-

3. Orton, F. H.: Crown- and Bridge-Work from New Point of View, J.A.D.A. 8:307 (April) 1921.

4. McLean, D. W.: D. Cosmos, 74:313 (April), 744 (Aug.) 1932.

5. Beach, J. W.: D. Summary, 36:441 (June) 1916.

6. Woodworth, J. G.: D. Cosmos, 64:290 (March) 1922.

bilization should not be necessary. In upper cases, sufficient auxiliary stabilization may be gained by passing a broad flat connector of metal across the anterior part of the palate, following the line of the anterior teeth, but keeping 4 or 5 mm. away from them.

The brief assistance gained by fractional stabilizers which rest against one or two anterior teeth is dearly bought. The inclined plane surfaces of these teeth are subjected to a stress load that is exaggerated by the distance at which it is applied to the stabilizing levers. Such devices are perverted orthodontic appliances, and sure-fire producers of periodontoclasia.

Attachments proper are of two kinds: (1) those placed within the convexity of the tooth and (2) external attachments.

Internal attachments: The principles involved in the precision attachment were presented by Dr. Parr in the eighties[7] and the device was placed within the tooth convexity by Morgan in 1901.[8] It reached a high point of development in the hands of Chayes, to whom goes credit for its present usefulness.

There is some discussion as to the justification for cutting teeth for internal attachments; and clasps are often used where they are contraindicated, merely to avoid cutting the abutment to receive an inlay.

Once determine that the type of replacement for which the cutting is to be done is the type which will provide the most efficient masticatory function, and the longest life to the abutments and their periodontium, and the cutting of a sound tooth fades into insignificance. Worse calamities may befall an abutment tooth than that of carrying a good inlay.

The use of positioning mandrels, with shafts cut short enough to permit their introduction into the posterior part of the mouth, will prevent excessive cutting; and the roentgenogram provides information as to the position and size of the pulp. Aside from the hazard of deep caries, involvement of the pulp in preparing abutments for precision attachments is rare.

While, theoretically, the male members of precision attachments can move in their sleeves under the stresses of mastication, such movement, like that of healthy natural teeth in their sockets, is more theoretical than real. Properly adjusted modern precision attachments lock rigidly in the abutment teeth. The bottoms of the sleeves being closed, the male members slide to that point, and there the stress load is sustained by the abutment teeth.

Tipping stresses due to pressure upon the mucosa borne denture, and the lateral thrusts of mastication, are transmitted to the abutments more positively through precision attachments than through clasps. This basic principle of precision attachments cannot be too strongly stressed. Used without distal extension or some other form of stressbreaker, the modern precision attachment renders the partial denture strictly tooth borne, until the abutments have been moved or loosened and the denture is lowered to the level of full mucosa compression.

Chayes believed that every tooth should move during the function of chewing. He not only arced his attachments to permit independent mobility of the abutments and the bridge assembly, but also, in some cases, applied the principle by extending laterally a bar of metal, which was received into a box in the adjoining

7. Parr, H. E., in Evans, George: Artificial Crown- and Bridge-, Porcelain-Work, Ed. 8, Philadelphia: P. Blakiston's Son & Co., 1920, p. 359.

8. Morgan, J. P., in Evans, George (Footnote 7), p. 466.

pontic and fastened there with a screw.[9] Wear, or judicious filing, developed play in this joint, so that the pontic moved independently of its neighbor. The same device, applied between the attachment and the mucosa borne denture, constitutes the modern distal extension stressbreaker. The McCollum modification offers, in addition to the straight bar, extensions in angles of 15 and 30 degrees, for facility in placing the extension between the ridge and the occlusal surfaces.

The combination of perfectly paralleled precision attachments, precompression of the mucosa, proper tooth arrangement, coordinated occlusion, judicious saddle design and resilience of connectors, and suitable stress equalizers, provides, in my experience, the ideal partial denture. Repeatedly, I have seen appliances of this type worn for periods of from eight to a dozen years, until their movable parts were completely worn out; and then replaced, using the same abutment teeth, which were still as healthy as any teeth in the mouth. It is regrettable that the time required to produce such an appliance makes of what should be every man's necessity a luxury for the few.

Until all patients are wealthy, or until dentistry is socialized in some way far more adequate than any so far suggested, external attachments in some form of clasp will continue to be used in the vast majority of partial denture cases.

External attachments: Early partial dentures had loosely fitting clasps of wrought plate, and rode freely upon the compressible mucosa, settling into it and destroying the ridge beneath. Their clasps wore the abutment teeth, inducing caries. As the denture settled, the clasp arms lacerated the gingivae, periodontoclasia resulting.

9. Chayes, H. E. S., in Evans, George (Footnote 7), p. 472. Doxtater, L. W.: Items Int., 52:875 (Nov.) 1930.

The natural teeth against whose inclined plane surfaces the denture edge rested for auxiliary stabilization were subject to wear and lateral stress, both of which increased as the denture settled. The teeth were "orthodonted" and loosened; and became sensitive to sweet, sour and salt and thermal change, and, finally, to every movement of the denture upon their abraded surfaces. In the end, the patient parted with the contraption with relief.

The first step toward the solution of those early problems came when Bonwill added to the clasp the occlusal rest. With the advent of the casting process, Nesbett cast the clasp and rest in one piece for use as an attachment for small tooth borne bridges.

Soon, over Nesbett's protest, the cast clasp was being used for the stabilization of partial dentures. It stabilized them beautifully—until the abutments were pried loose and could rock also.

The challenge of this state of affairs soon brought forth stressbreakers of two types. One broke abutment torque by placing between denture and abutment a sliding or movable joint. The sliding joints have proved too restricted in movement, and most of the others not restricted enough; for too much independent mobility of the partial denture destroys the ridge, and too little destroys the abutment periodontium.

The second type of stressbreaker depends on the resilience of either the denture connectors or the clasp-arms. An example of the former is the grasshopper leg lingual bar, or the swing-back type of construction developed by Rudd.[10] The more recent designs of Neurohr[11] follow

10. Rudd, M. B.: Cosmos, 65:1157 (Nov.) 1923.

11. Neurohr, F. G.: Spring Lock Dental Restoration and Distal Extension Bridge Designed upon This Principle, J.A.D.A., 21:788 (May) 1933.

the same principle. Many current partial dentures place sole reliance for stress-breaking on the resilience of the clasp arms.

Conceded that all clasps must have minimal tooth coverage and must support the abutment squarely against the lateral thrust of the occlusal rests, the partial denture clasp must follow one of two distinct principles: either it must be rigid, and have some device to break abutment torque or it must have a predetermined resilience, calculated to break that torque.

Theoretically, it should be possible to balance the resilience of metal against the resilience of the mucosa. Clinical experience establishes the fact that a clasp sufficiently resilient to break torque is usually too resilient to stabilize the denture satisfactorily. Most denture clasps seen clinically are too rigid for the safety of the abutment periodontium. In strong bone, they move the abutments to a new angle and eventually destroy them. When the supporting bone is soft, the abutments are more quickly lost. In both cases, the denture is lowered from its occlusal contacts and, therefore, chewing efficiency is reduced.

When sudden vertical pressure is applied to the posterior, or free, end of a partial denture, the shock is transmitted sharply to the abutment through the mesial bearing points of the clasp arms as well as through the occlusal rest. The clasp arm pressure tapers off as the inertia of the metal is overcome and the clasp arms begin to bend and move upon the abutment tooth. This initial shock, gradually tapering off, is characteristic of all resilient metal stressbreakers.

The precision attachment or the rigid clasp with a well-regulated distal extension stress equalizer presents quite a different picture. Owing to the mobility of the stress equalizer, the mucosa takes the first brunt of the stress load. As the mucosa reaches its limit of compressibility, the stress equalizer reaches its limit of mobility. The abutment tooth then takes up its share of the burden.

DISTAL EXTENSION STRESS EQUALIZERS FOR CLASPS

While the distal extension stress equalizer was designed for use with precision attachments, it may be used with Nesbett or Roach clasps. For this purpose, or for use with small vulcanite base bridges, the Roach clasp should be designed and cast as a unit. The clasp arms unite below the occlusal rest instead of attaching independently to the denture saddle.

An extension bar of platinum-iridium may be waxed into the wax pattern of either type of clasp and the clasp cast about it. Solder completes the union. Or the distal extension bar may be made of wax, molded in the slightly oiled housing box of a McCollum distal extension attachment. This wax extension bar is tacked to the wax clasp with inlay wax and the unit is cast. It is well to wax and cast all clasps on the same model that the extensions may be roughly paralleled.

Sheet casting wax is wrapped about the newly cast extension bar and over its distal end. If the appliance is to be of vulcanite, a loop of wax rope is added to the distal end for retention in the plastic denture base. The box is then cast and is adapted to the extension bar, and both are drilled to receive a threaded platinum-iridium wire. The wire is left long enough to project well beyond the finished denture.

The box is now filled with soft plaster and slipped on over the distal extension. The threaded wire is introduced and the plaster is allowed to set. The case is then waxed and vulcanized, after which the wire is unscrewed with pliers, and the distal extension is disassembled and freed of plaster. After the denture is polished,

the extension is arced, if desired, and reassembled. The wire is cut off flush with the vulcanite surface and given a slot to receive a screwdriver.

Extensions made in this manner develop mobility more rapidly than the factory made type. When mobility is needed at once, the distal extension bar is filed at the posterior end of its upper surface, and at the anterior end of its lower surface. The cut tapers to nothing at the middle of the extension. The screw hole is slightly enlarged in the appropriate direction.

MAINTENANCE OF PARTIAL DENTURES

Important factors in the maintenance of partial denture stabilization and function are: (1) the relining of saddle units when and if indicated, and (2) the renewal of distal extension bars when they have developed too great mobility. The procedure for relining is too well known to require discussion, except to suggest the use of the new impression cements.

Distal extension bars may be renewed in three ways: by replacing the old factory made precision attachment with a new one; by waxing and casting onto the old extension, whether it was factory made or home cast, or by flowing wax into the oiled housing box to make the pattern, and then casting a new extension.

The partial denture must provide and maintain masticatory function if it is to justify its existence. It must do so with minimal injury to its resilient and nonresilient support. It cannot accomplish these things through any single step or device. There is no cureall or shortcut. Its perfection is only attained by the perfect development of each of the factors enumerated.

SUMMARY

The well-executed partial denture, built about a nucleus of natural teeth, is more efficient functionally than is a full denture.

The fundamental problem of the partial denture is that of efficient and salubrious stabilization.

Stabilization of the partial denture calls for the equalizing of stress upon resilient mucosa support and nonresilient tooth support, and presents two basic problems; to reduce mucosa resilience and to minimize torque on the abutments.

Mucosa resilience is reduced by surgical removal of excessive masses of soft tissue, by precompression gained by wearing preliminary dentures and by the impression technic.

Stress load, and therefore torque, is reduced by so placing denture teeth that there will be minimal leverage upon the denture; and by coordinating their cusps and fossae to provide maximum masticating efficiency without cuspal antagonism.

Abutment torque is broken by the use of stress equalizers. These may be of resilient metal or of movable parts. The distal extension stress equalizer provides a controllable equalization which, on analysis, is superior to stress equalization by means of resilient metal. Its parts are susceptible of renewal, when worn out.

There is no cureall or shortcut to successful partial prosthesis. Every factor and each step in their design and construction must be carefully developed.

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STUDY OF THE CAUSES OF DISCONTINUITY OF METAL IN SPRUES DURING PRESSURE-CASTING*

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ANYONE who has used the casting process in the construction of dental inlays and appliances is familiar with a certain type of defect arising from the failure of the metal to maintain, on solidification, the shape of the sprue into which it is cast. (In the casting of metal, the term "sprue" is defined as (*a*) the ingate through which molten metal is poured into the mold; (*b*) the waste piece of metal cast in the ingate; (*c*) a piece of metal, wood or wax used in making the ingate. Since it is imperative that separate terms be used for these meanings, the following definitions are substituted: *Sprue*—the ingate through which the molten metal passes from the crucible to the pattern chamber. *Sprue former*—the wax, wood, or metal piece used to form the ingate or sprue. *Stem*—the portion of metal cast in the sprue. *Residue button*—the surplus portion of metal remaining in the crucible.) The accompanying photographs, which show some of these casting defects in the form of incomplete distribution of metal in the sprues, were taken of actual castings selected from a hundred experimental cases. The specimens were prepared by sectioning the investment molds without disturbing any part of the cast metal. In each case, an attempt was made to preserve at least one half of the crucible, sprue and pattern chamber. These were mounted in plaster blocks and photographed. The defect will usually manifest itself in the form of a constriction in some area of the stem (Fig. 1) or in a separation of the connection between the casting proper and the residue button (Fig. 2). The constriction or disconnection may occur at the junction of the stem and the residue button (Fig. 3); or at the junction of the stem and the casting proper (Fig. 4); or throughout the stem itself (Fig. 5). Since, in any case, the defect is a result of the lack of continuity of metal in the sprue during casting, the term "discontinuity of metal in sprues" is suggested to describe these casting anomalies. The subject is of considerable importance because the condition is often accompanied by an incomplete filling of the pattern chamber with metal or more generally by imperfections in the casting adjacent to the stem.

Study was undertaken (*a*) to determine, by experimental procedure, the operative causes of this type of faulty casting and (*b*) to propose a hypothetical explanation of the result in terms of the behavior of the metal. (The term "operative causes" means the manipulative acts under control of the operator which produce a certain effect.)

OPERATIVE CAUSES OF DISCONTINUITY OF METAL IN SPRUES

A search of the literature disclosed many illogical interpretations of the phe-

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nomena, but failed to furnish any information relative to those causes under control of the operator. One eminent author, in explaining the reason for the separation of the residue button from the casting, says:

> If the sprue is quite large, and the gold residue button large, the residue remains fluid for a considerable period of time after the casting pressure has been applied, and there appears to be a tendency for the large button to draw to it the gold of the casting through the medium of the large gate (the sprue). A large button of gold very often draws only part of the sprue to it, thus separating the connection between the residue button and the casting, and arresting the exercise of the casting pressure which would otherwise be transmitted from the button to the sprue and to the casting proper.

This theoretical explanation, in the light of experimental data contained in this article, is in error. It is quoted here because it is typical of the interpretation most generally assigned to these casting irregularities.

It is possible that the author of the foregoing statement did observe discontinuity of metal in sprues, even under the conditions that he describes, but the cause cannot be attributed, as he suggests, to the large sprue and large residue button. If that explanation was valid, such imperfections would be observed in every casting where large sprues and large residue buttons are used.

It has also been suggested that the discontinuity of metal in sprues during casting may be caused by the use of sprues that are too small in proportion to the size of the casting proper and the residue button.

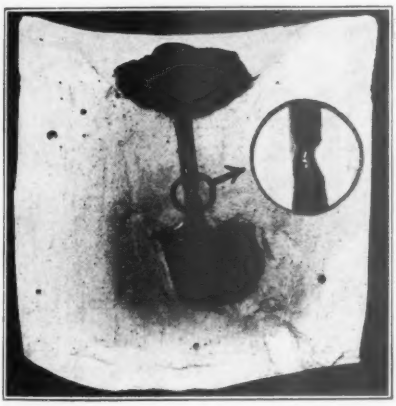

Fig. 1.—Constriction of metal in stem. The inset shows an enlargement of the constricted area. The casting is otherwise complete.

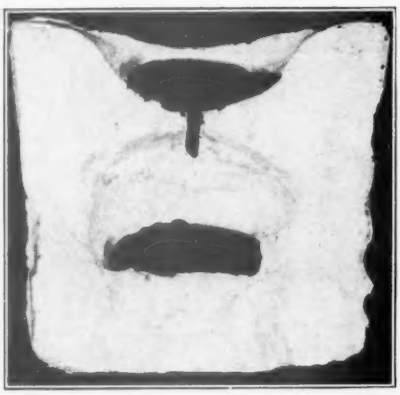

Fig. 2.—Disconnection of metal in stem. The casting proper is not complete and presents a tubercle of metal at the point where the sprue former was attached.

In refuting these claims, a series of more than a hundred experiments were carried out in which all casting conditions were accurately controlled and variations were made only in the size of the sprues, the patterns and the residue buttons. In none of these experiments did there occur a constriction of the stem or a disconnection between the residue button and the casting proper.

It must be remembered that, in the experience of the average dentist, the discontinuity of metal in sprues during casting is not a common occurrence. It is for this reason, as well as because there are numerous factors in the failure of a particular casting, that only speculative information is available regarding the causes of these defects.

It seems reasonable to assume that an explanation of these casting anomalies is valid only when it can be substantiated by laboratory tests. In other words, it is only when these unusual casting defects can be consistently produced at will under controlled conditions that a definite statement as to the cause seems justified.

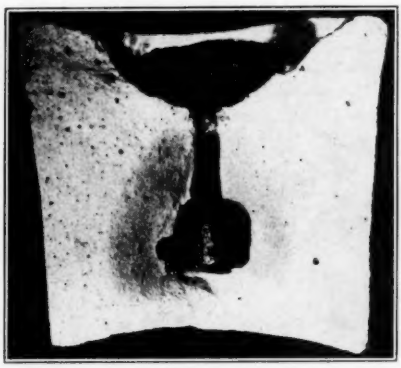

Fig. 3.—Disconnection of metal in stem. The casting proper and major portion of stem are complete.

It was upon this premise that I proposed to show experimentally that the discontinuity of metal in sprues during casting can be produced at will by any one of the following conditions: (1) insufficient pressure to complete the casting; (2) insufficient heating of the casting metal allowing the residue button to solidify before the pattern chamber and sprue are filled, and (3) an insufficient amount of surplus metal to keep the sprue filled during the casting operation. These, with accompanying experimental data, will be discussed in the order named.

EXPERIMENTS PRODUCING DISCONTINUITY OF METAL IN SPRUES

In an effort to prove that the discontinuity of metal in sprues can be produced by an insufficiency of pressure during the casting operation, the following series of experiments were performed. A direct-pressure casting machine was adjusted during a series of trial castings until the reading on the pressure gage indicated a point just short of the degree of pressure required to advance the molten metal from the crucible into the sprue. This gage reading was then increased slightly to a point where the pressure was sufficient to advance the metal into the sprue, but was insufficient to insure the complete filling of the pattern chamber. With the machine adjusted in this manner, twenty-five consecutive castings were made under the following conditions:

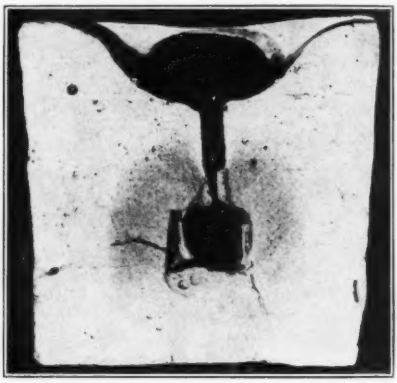

Fig. 4.—Constriction of metal in stem. The casting proper is incomplete.

1. *Patterns.*—Differently shaped pieces of wax were carved, varying in magni-

tude to be equivalent to one half, 1 and 2 pennyweight when reproduced in metal.

2. *Sprues.*—The sprue formers (one to each pattern) were varied in length between 6 and 12 mm. and in diameter between 9 and 20 gage (B & S).

3. *Mold Temperature.*—In each case, the mold was heated in an electric furnace to approximately 650 C. (1202 F.).

4. *Casting Metal.*—Standard inlay gold, in amounts ranging between 3 and 5 pennyweight, was used to make the castings. In each case, the metal was heated with an oxygen and gas blowpipe until it very closely approached white heat. It should be noted that precautions were taken to eliminate such probable sources of error as an insufficient amount of surplus metal, insufficient heating of casting metal and insufficient mold temperature. As a result of this series of experiments, either constriction of the stem or a disconnection between the residue button and the casting proper occurred in twenty-three of the twenty-five cases. The conditions under which these castings were made and the results are tabulated in Table 1. In Experiment 11, the pressure was insufficient to advance the metal into the sprue, and in Experiment 19, it was sufficient to effect a complete casting without defects.

Fig. 5.—Constriction of metal in stem. The constriction extends from the residue button to the casting proper. The latter is complete.

A second series of twenty-five consecutive castings were made in an effort to prove that the discontinuity of metal in sprues can be produced by insufficient heating of the casting metal beyond its fusing point. The conditions under which these castings were made are as follows:

1. *Patterns.*—Differently shaped pieces of wax were carved, varying in magnitude to be equivalent to one half, 1 and 2 pennyweight when reproduced in metal.

Fig. 6.—Disconnection of metal in stem. The threadlike projection of metal from the residue button is hanging freely in the sprue. The casting proper is incomplete.

2. *Sprues.*—The sprue formers (one to each pattern) were varied in length between 6 and 12 mm. and in diameter between 9 and 20 gage (B & S).

3. *Mold Temperature.*—In each case the mold was heated in an electric furnace to approximately 650 C. (1202 F.).

TABLE 1.—CASTING CONDITIONS AND RESULTS OF EXPERIMENTS TO PROVE THAT DISCONTINUITY OF METAL IN SPRUES CAN BE PRODUCED BY INSUFFICIENT PRESSURE

Experiment	Pattern (Magnitude In Dwt. Equivalents)	Sprue*		Mold Temperature Centigrade (Approximate)	Casting Alloy		Casting Pressure	Results		Remarks
		Length Mm.	Gage (B&S)		Amount Dwt.	Temperature		Positive	Negative	
1	½	6	20	650	3	High	Low	+		Disconnection
2	1	6	14	650	5	High	Low	+		Disconnection
3	2	10	20	650	3	High	Low	+		Constriction
4	1	10	12	650	4	High	Low	+		Disconnection
5	½	12	9	650	3	High	Low	+		Disconnection
6	1	8	14	650	5	High	Low	+		Constriction
7	2	8	16	650	4	High	Low	+		Constriction
8	½	10	18	650	4	High	Low	+		Constriction
9	1	8	20	650	5	High	Low	+		Disconnection
10	2	12	16	650	4	High	Low	+		Disconnection
11	½	6	18	650	3	High	Low		—	Metal did not cast
12	2	8	12	650	5	High	Low	+		Constriction
13	½	12	14	650	5	High	Low	+		Disconnection
14	1	10	12	650	4	High	Low	+		Constriction
15	2	6	10	650	3	High	Low	+		Disconnection
16	½	8	14	650	3	High	Low	+		Disconnection
17	1	6	9	650	4	High	Low	+		Constriction
18	½	8	20	650	5	High	Low	+		Disconnection
19	2	10	16	650	5	High	Low		—	Complete casting
20	2	6	14	650	3	High	Low	+		Constriction
21	1	12	18	650	5	High	Low	+		Disconnection
22	2	10	16	650	4	High	Low	+		Constriction
23	1	6	14	650	4	High	Low	+		Disconnection
24	½	12	18	650	3	High	Low	+		Constriction
25	1	10	20	650	5	High	Low	+		Constriction

*All castings were made with one sprue.

4. *Casting Metal.*—Standard inlay gold, in amounts ranging between 2 and 4 pennyweight, was used to make the castings.

5. *Casting Pressure.*—The pressure readings on the gage of the machine were varied from a minimum of 10 to a maximum of 15 pounds per square inch. Previous to each casting, the metal in the crucible was heated to a temperature only very slightly beyond the fusing point. Some difficulty was encountered in visually determining this point, since no electrical equipment for temperature measurements was available. Consequently, the metal in three of the castings was heated sufficiently to allow its complete distribution in the pattern chamber and sprue without defects, and, in two of the cases, it was not entirely fused, its failure to advance into the sprue resulting. Notwithstanding these errors, the remaining twenty castings showed imperfections either in the form of a constriction in the stem or in a disconnection between the residue button and the casting proper. It should be observed that, under the conditions described, all factors, apart from the temperature of the casting metal, which might have produced discontinuity of metal in the sprue, were definitely controlled. The conditions under which these castings were made and the results are tabulated in Table 2.

Fig. 7.—Constriction of metal in stem. The constriction extends from the residue button to the casting proper. The latter is incomplete.

The third series of experiments, comprising twenty-five consecutive castings, were performed in an effort to prove that the discontinuity of metal in sprues can be effected by the use of an insufficient amount of surplus metal to keep the sprue filled during the casting operation. The following conditions were provided in these experiments:

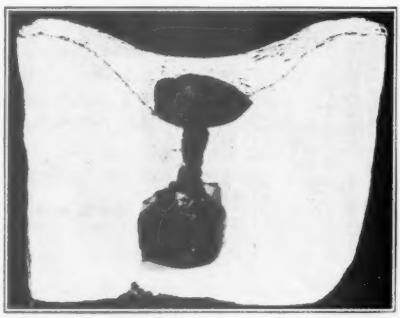

Fig. 8.—Constriction of metal in stem. The residue metal is in the form of a thin, concave film. The stem is hollow and the hole in its side connects with the one in the center of the residue button.

1. *Patterns.*—Differently shaped pieces of wax were carved, varying in magnitude to be equivalent to one half, 1 and 2 pennyweight when reproduced in metal.

2. *Sprues.*—The sprue formers (one to each pattern) were 6 and 12 mm. in length, and 9, 14 and 18 gage (B & S) in diameter.

3. *Mold Temperature.*—In each case, the mold was heated in an electric fur-

*All castings were made with one sprue.

TABLE 2.—CASTING CONDITIONS AND RESULTS OF EXPERIMENTS TO PROVE THAT DISCONTINUITY OF METAL IN SPRUES CAN BE PRODUCED BY INSUFFICIENT HEATING OF CASTING METAL

Experiment	Pattern (Magnitude In Dwt. Equivalents)	Sprue*		Mold Temperature Centigrade (Approximate)	Casting Alloy		Casting Pressure	Results		Remarks
		Length Mm.	Gage (B&S)		Amount Dwt.	Temperature		Positive	Negative	
1	½	6	20	650	2	Low	10	+		Disconnection
2	1	6	14	650	4	Low	12	+		Disconnection
3	2	10	20	650	3	Low	15	+		Constriction
4	1	10	12	650	4	Low	10		—	Metal did not cast
5	½	12	9	650	2	Low	12	+		Disconnection
6	1	8	14	650	3	Low	10	+		Constriction
7	2	8	16	650	4	Low	15	+		Disconnection
8	½	10	18	650	3	Low	12		—	Complete casting
9	1	8	20	650	2	Low	10	+		Disconnection
10	2	12	16	650	4	Low	15	+		Disconnection
11	½	6	18	650	2	Low	15	+		Constriction
12	2	8	12	650	3	Low	12		—	Complete casting
13	½	12	14	650	2	Low	10	+		Constriction
14	1	10	12	650	4	Low	15	+		Disconnection
15	2	6	10	650	3	Low	12	+		Disconnection
16	½	8	14	650	4	Low	15	+		Constriction
17	1	6	9	650	2	Low	12		—	Complete casting
18	½	8	20	650	3	Low	15	+		Disconnection
19	2	10	16	650	4	Low	10		—	Metal did not cast
20	2	6	14	650	2	Low	12	+		Constriction
21	1	12	18	650	3	Low	15	+		Disconnection
22	2	10	16	650	4	Low	10	+		Constriction
23	1	6	14	650	3	Low	15	+		Disconnection
24	½	12	18	650	2	Low	12	+		Disconnection
25	1	10	20	650	4	Low	10	+		Constriction

*All castings were made with one sprue.

nace to approximately 650 C. (1202 F.).

4. *Casting Metal.*—Standard inlay gold was used to make the castings. In each case, the metal was heated with an oxygen and gas blowpipe until it very closely approached white heat.

5. *Casting Pressure.*—The pressure readings on the gage of the machine were varied from a minimum of 10 to a maximum of 15 pounds per square inch. With these varying conditions, it was necessary to compute, in each case, the amount of metal required to fill the sprue and pattern chamber. This amount was increased by one-eighth pennyweight to provide for a small residue button, yet the total mass remained insufficient to insure complete coverage of the sprue opening in the final stage of the casting. Nevertheless, in two of the castings, the small amount of residue metal did remain directly over the sprue and prevented discontinuity of the metal. In the remaining twenty-three cases, the residue metal in the crucible was either penetrated or blown to one side of the sprue opening, which allowed air to enter the sprue and interrupt the filling of this portion of the mold cavity. Most of these castings presented a hole in the residue button and hollow areas in the stem. One of these castings is shown in Figure 8. Since all other factors which might have produced an incomplete casting were eliminated, the discontinuity of metal occurring in these cases could be attributed only to the insufficiency in amount of residue metal. The conditions under which these castings were made and the results are tabulated in Table 3.

The three series of experiments just described are briefly summarized as follows: 1. Seventy-five consecutive castings were made in an effort to prove that constriction or disconnection in the stem can be produced at will by insufficiencies in casting pressure, temperature of casting metal and amount of residue metal. 2. The results show that casting defects of the nature described were produced in sixty-six of the seventy-five trials; or in 88 per cent of the castings made.

HYPOTHETICAL EXPLANATION OF BEHAVIOR OF METAL

Up to this point, the discontinuity of metal in sprues has been discussed from the standpoint of the causes that are directly under control of the operator and can be validated by laboratory experiments. The remainder of this paper will embrace a hypothetical explanation of these casting anomalies in terms of the behavior of the molten metal arising from the operative causes described. In accounting for this unusual behavior of the metal, three physical factors are suggested: surface tension, gravity and contraction. Before discussing these factors, it should be pointed out that they are always existent in the casting of metal; yet all casting does not result in discontinuity of the metal in the sprue. Careful attention is, therefore, directed to a study of the influence of these factors on the behavior of liquid metals under varying casting conditions.

Surface tension has been defined as the contractile force or tension exhibited by the free surface of liquids. Smith[1] states that "the surface of a liquid has the appearance of being covered with a thin elastic film . . . it requires a force to break this film . . . the amount of this force depends on the nature of the liquid." Since molten metals have a higher surface tension than any other class of liquids, they exhibit a strong tendency to remain in spheroidal form. Thus, under customary casting conditions, we observe that molten metal when resting over a verti-

1. Smith, A. W.: Elements of Physics, Ed. 2, New York City: McGraw-Hill Book Company, 1927, p. 108.

*All castings were made with one sprue.

TABLE 3.—CASTING CONDITIONS AND RESULTS OF EXPERIMENTS TO PROVE THAT DISCONTINUITY OF METAL IN SPRUES CAN BE PRODUCED BY INSUFFICIENCY IN AMOUNT OF SURPLUS METAL

Experiment	Pattern (Magnitude In Dwt. Equivalents)	Sprue*		Mold Temperature Centigrade (Approximate)	Casting Alloy		Casting Pressure	Results		Remarks
		Length Mm.	Gage (B&S)		Amount Dwt. Grains	Temperature		Positive	Negative	
1	½	6	9	650	1–1	High	10	+		Incomplete casting†
2	1	12	14	650	1–13	High	12	+		Incomplete casting†
3	2	12	18	650	2–6	High	15	+		Incomplete casting†
4	1	6	9	650	1–13	High	10	+		Incomplete casting†
5	½	12	14	650	1–1	High	12	+		Incomplete casting†
6	1	6	18	650	1–4	High	10		—	Complete casting
7	2	6	9	650	2–13	High	15	+		Incomplete casting†
8	½	12	14	650	1–1	High	12	+		Incomplete casting†
9	1	12	9	650	1–22	High	10	+		Incomplete casting†
10	2	6	18	650	2–4	High	15	+		Incomplete casting†
11	½	12	14	650	1–1	High	15	+		Incomplete casting†
12	2	12	9	650	2–23	High	12	+		Incomplete casting†
13	½	6	18	650	0–16	High	10	+		Incomplete casting†
14	1	6	18	650	1–4	High	15	+		Incomplete casting†
15	2	12	9	650	2–23	High	12	+		Incomplete casting†
16	½	12	14	650	1–1	High	15	+		Incomplete casting†
17	1	12	18	650	1–6	High	12	+		Incomplete casting†
18	½	6	14	650	0–20	High	15	+		Incomplete casting†
19	2	6	9	650	2–13	High	10	+		Incomplete casting†
20	2	12	18	650	2–6	High	12	+		Incomplete casting†
21	1	6	14	650	1–8	High	15	+		Incomplete casting†
22	2	12	9	650	2–23	High	10		—	Complete casting
23	1	12	14	650	1–13	High	15	+		Incomplete casting†
24	½	6	18	650	0–16	High	12	+		Incomplete casting†
25	1	12	14	650	1–13	High	10	+		Incomplete casting†

*All castings were made with one sprue.
†The incompleteness refers only to the sprue.

cal sprue of conventional diameter does not run into the hole of its own accord; i.e., without an applied force. This is because the surface tension of the molten metal in the crucible is greater than the weight of the column of metal resting directly over the hole. (An approximate measure of the surface tension of a mass of metal resting over the sprue can be made by multiplying the circumference of the hole by the surface tension value for the liquid metal in question. The weight of the column of metal resting over the sprue is the product of the cross-section area of the sprue opening, the height of the column of metal over the sprue opening and the specific gravity of the particular metal. The remaining portion of the metal in the crucible exerts a pressure perpendicular to the surface of the column and, therefore, can have no effect in either supporting it or pressing it down.)

When the cross-section area of the sprue is increased to a point where the weight of the column of metal resting over the sprue exceeds the cohesive force tending to hold the metal in globular form, a portion of the metal will drop into the opening; but not all of the metal needed to fill the mold cavity will flow in from the crucible, for as soon as the weight of the column resting over the sprue is reduced below the surface tension of the metal, the flow will cease. Moreover, the portion of metal having separated itself from the mass in the crucible will fall to the lowest part of the pattern chamber, tend to assume a spheroidal form and leave little or no connection between itself and the part remaining in the crucible. This condition is illustrated in Figure 6.

The manner in which the descending portion of metal separates itself from the quantity in the crucible is suggested in a study of liquid jets. Crew[2] explains that when a large drop of oil is held by surface tension between two wire rings in a mixture of alcohol and water of the same density as oil, the globule of oil will elongate itself, when the rings are moved apart, in the same manner that it would if the oil were falling freely under gravity from a nozzle. He states that "the column of oil becomes unstable when its length exceeds its circumference, and the surface tension proceeds first to form a sort of waist and then to pinch the column in two" and "instantaneous photographs of jets of water, falling freely, show that they are pinched off by surface tension in precisely this manner." Concerning similar behavior in jets of liquid metal, Carhart[3] states: "When molten lead flows from a small orifice, the surface tension around the small stream throttles it and cuts it into segments." Hence, it seems logical to assume that the portion of metal falling into the mold cavity will separate itself from the mass in the crucible in a like fashion, leaving the sprue, in most instances, devoid of metal.

While the preceding discussion of the effect of surface tension on the behavior of liquid metal has referred to the premature entrance of metal into the mold cavity under no applied casting force, it explains similar behavior of the metal when it is ineffectively cast, resulting in discontinuity in the sprue. If the flow of metal through the sprue during pressure-casting is suddenly interrupted before the pattern chamber is completely filled, the portion of metal in the pattern chamber may likewise be pinched off from that remaining in the sprue, as shown in

2. Crew, Henry: General Physics, Ed. 4, New York City: The Macmillan Company, 1928, p. 189.

3. Carhart, Henry: College Physics, New York City: Allyn and Bacon, 1918, p. 107.

*All castings were made with one sprue.
†The incompleteness refers only to the sprue.

Figure 4. Under such conditions, the sprue will not be left devoid of metal unless the sprue is extremely short. It can be proved that the molten metal in a sprue of conventional length (not less than 5 mm.) will not be drawn back into the crucible because of its weight, its surface tension and the frictional resistance offered by the surrounding investment walls; neither will the metal, in the absence of pressure, advance into the pattern chamber. For this reason, some of the metal will usually be retained in the sprue whether the deficiency responsible for the incomplete casting is in the applied pressure, the heating of the metal or the amount of residue metal.

On the other hand, if the sprue is sufficiently short to bring the pattern chamber into close proximity to the crucible, the metal in the sprue, under ineffective casting conditions, may be drawn either into pattern chamber or into the crucible, the sprue being left devoid of metal.

Observation of the conditions under which these casting defects occur seems to indicate that whether the discontinuity of metal in the sprue results in a constriction of the stem or in a separation of the connection between the residue button and the casting proper depends, at least in some cases, on the extent to which the pattern chamber is filled with metal before the flow is interrupted; and on the magnitude of the residue button and the casting proper in proportion to the size of the sprue.

If the flow of metal is interrupted after only a portion of the pattern chamber is filled, this mass of metal, owing to its weight and surface tension, will be drawn away from that portion in the sprue; which results in its separation from the stem. This presupposes the use of a relatively small sprue allowing the stem to congeal in advance of that portion in the pattern chamber. This behavior of the metal is illustrated in Figure 2.

If the sprue is so large that the stem remains molten for a longer time, it is possible that the major portion of the metal in the sprue, will, partly because of its weight, be drawn into the pattern chamber, as shown in Figure 5. Obviously, the extent to which this occurs will depend on the interim during which the residue button remains fluid and on the length of the sprue.

On the other hand, if the pattern chamber and sprue are completely filled with metal before the casting pressure ceases or the metal congeals, and discontinuity of the metal in the sprue results (Fig. 1), the cause cannot be explained by surface tension and gravity. In other words, after the pattern chamber is completely filled, why does the metal occupying the sprue fail to maintain its continuity? The answer is to be found in a study of the thermal contraction of gold and some of its alloys.

The metals used in the casting process undergo changes of volume in the form of shrinkage or contraction on passing from the liquid to the solid state. The shape of the casting, with respect to thin and thick portions, will regulate the manner in which cooling occurs. Thus, the shrinkage of metal when various areas of the casting have different rates of cooling may cause one portion of the solid metal to be drawn away from another portion, discontinuity of the metal in the sprue resulting.

Such an explanation is paradoxical when we consider that while the metal occupying the sprue always contracts on cooling, the effect is not always discontinuity. This would seem to indicate that these metals, under certain casting conditions, possess quite varying coefficients of expansion through identical tempera-

ture ranges from one time to another. While the thermal contraction of these metals in the solid state remains constant, there is much evidence that it does vary in the liquid state when the metal is subjected to the conditions set forth by the casting process. Therefore, if the discontinuity of metal in sprues during casting is to be attributed to the shrinkage of the metal on solidification, it must be shown that the casting conditions do have a bearing on the location and extent of this contraction.

Coleman[4] has divided the casting shrinkage of gold into three parts: (1) the contraction of the liquid metal on cooling from the temperature at which it enters the mold to the freezing point; (2) the contraction of the metal on changing from the liquid to the solid state at constant temperature (1,063 C. [1,945 F.] for pure gold) and (3) the contraction of the solid gold on cooling from the freezing point to room temperature.

He reported the Bureau of Standards' measurement for the linear contraction of a gold-copper alloy (90 Au, 10 Cu) from the melting point to room temperature, as 1.62 per cent; whereas the average of the values for the net casting shrinkage of the same alloy was found to be 1.25 per cent.

Coleman suggests two explanations of this difference:

(1) There may be sufficient friction or interlocking between the casting and the walls of the mold to hold and stretch the casting while it is cooling through that range of temperature within which the metal is very soft and weak, thus preventing the full normal shrinkage, and (2) the compensation of part of the total shrinkage of the solid metal may be dependent upon a difference in the rates of cooling of different parts of the casting. If part of the metal in the mold solidifies and cools to some temperature below the melting point before the metal in the sprue freezes, the shrinkage due to the cooling of this solid metal may be compensated by the addition of metal from the crucible.

The shrinkage of the liquid metal before the sprue freezes obviously would be compensated by the addition of metal from the crucible if the casting pressure were maintained. If a crust of solid metal has formed around the outside surface of the casting before the central part of the casting freezes, the shrinkage of this central portion as it cools to the freezing point may produce voids or porosity previously referred to as localized shrinkage in the casting. Such localized shrinkage would not affect the outside dimensions of the casting.

In the case of shorter, bulkier castings the stretching force of the mold might not have so great an effect. The addition of more metal from the crucible would be less effective because of the relatively faster rate of freezing of the metal in the sprue. The shrinkage of such castings would probably be slightly greater than the values reported.

In 1910, Price[5] performed an experiment with a fused quartz mold to determine the amount of shrinkage of pure gold. The values he reported were 1.64 per cent linear contraction, due to change of state without change of temperature, and 2.20 per cent linear contraction from the freezing point 1,063 C. (1,945 F.) to 0 C. (32 F.).

It is not important here that his values for the shrinkage of pure gold differ somewhat from those reported by Coleman. It is important to note that Price, in his article, concludes that part of the contraction of the gold during casting may be compensated by the addition of

4. Coleman, R. L.: Physical Properties of Dental Materials, Bur. Standards J. Res., December, 1928, pp. 908-911.

5. Price, W. A.: Laws Determining Behavior of Gold in Fusing and Casting, D. Cosmos, 53:283-289 (March) 1911.

molten gold from the sprue. Regarding this control of the location of the contraction of gold, he says:

> Probably no dentist who has done casting has failed to see that frequently there was a hole or depression in the side of the casting, or even a complete separation between the sprue and the inlay. This is the result or expression of the contraction due to change of state; it is, however, an error that we can control entirely. While we cannot prevent contraction due to change of state, we can control its location. In other words, we can, by forcing in molten gold from the sprue to take the place of the accumulated contraction in the inlay, cause all the contraction due to change of state to appear in the sprue. This can only be done by having the gold in the sprue molten when that in the inlay is crystallized, which can best be secured by having the mass of gold in the sprue large in proportion to the inlay, and by using a high enough pressure to move the gold in; also by using a relatively large gate, and having the investment sufficiently heated so that the gold will not be quickly chilled in the gate.

Thus, it is contended by Price and Coleman that the shrinkage of the liquid metal before the sprue freezes is compensated by the addition of metal from the crucible if the casting pressure is maintained.

It should be borne in mind that according to the description of the experiments reported by Coleman to determine the net casting shrinkage of pure gold and some of its alloys, the value of 1.25 per cent was derived under the casting conditions which he himself stated were effective in compensating for the contraction of the metal due to change of state. (The castings were made on an air-pressure machine with pressures ranging from 5 to 20 pounds per square inch. The patterns were not short and bulky, but, on the contrary, were approximately $3\frac{1}{4}$ inches long and $\frac{3}{25}$ inch in diameter. The size of the sprues is not given, but since some of the castings were made in molds at room temperature and others were made with the temperature of the metal at the lowest at which a casting could be made, it is obvious that they were large enough to keep the metal in the sprue molten while that in the pattern chamber was congealing.)

Unfortunately, we do not know what change might have occurred in the value of 1.25 per cent, if the shrinkage due to change of state had not been compensated; i.e., if the casting pressure had not been maintained or if the metal in the sprue had solidified before the casting proper, preventing the latter from drawing additional metal from the crucible.

In the light of the evidence presented, it seems reasonable to assume that the contraction of the solid metal from the freezing point to room temperature may, under certain unfavorable casting conditions, be augmented by the contraction that is due to change of state without change of temperature.

SUMMARY AND CONCLUSIONS

Results of the experiments described seem to indicate that the discontinuity of metal in sprues during pressure casting is caused by the following conditions, either separately or in combination: (1) insufficient pressure to complete the casting; (2) insufficient heating of the casting metal, allowing the residue button to solidify before the pattern chamber and sprue are filled, and (3) insufficiency in amount of surplus metal to keep the sprue filled during the casting operation.

The hypothetical explanation of these casting anomalies in terms of the behavior of the molten metal arising from the operative causes described may be summarized as follows:

1. When the discontinuity of metal in sprues is caused by insufficiency of pressure to complete the casting, the result is

explained by the fact that the magnitude of pressure is just enough to break the surface tension of the metal in the crucible and start it into the sprue, but is not sufficient to insure the complete filling of the pattern chamber and the sprue. When a higher degree of initial pressure is not sustained for a sufficient period of time, the normal shrinkage of the metal from the freezing point to room temperature may be augmented by the shrinkage that is due to change of state without change of temperature. The latter shrinkage, under normal casting conditions, is compensated by the addition of metal from the crucible if the casting pressure is maintained.

2. When the discontinuity of metal in sprues is caused by an insufficient heating of the casting metal, the result is explained by the fact that as soon as a small portion of the mass of metal in the crucible has advanced into the mold cavity, the residue button congeals, the flow of metal to the pattern chamber and the sprue being intercepted. Thus, the effect is the same as if the casting pressure is cut off.

3. When the discontinuity of metal in sprues is caused by an insufficiency in the amount of surplus metal, the result is explained by the fact that, before the casting is completed, air is permitted to enter the sprue and interrupts the distribution of the metal in the pattern chamber and the sprue.

In conclusion, I shall point out some of the most popular current theories advanced to explain the cause of the discontinuity of metal in sprues during casting, and attempt to show that, while they may be indirectly responsible for the result, the actual or direct cause, in each case, can be traced to one of the operative conditions already mentioned.

It has been suggested that the use of certain types of casting gold is frequently accompanied by "separated buttons." It must be remembered that pure gold and certain gold alloys have relatively high fusing points (or melting ranges) and, therefore, render superfusion more difficult. There is much evidence to support the contention that the discontinuity of metal in sprues was more prevalent in the days when pure gold was used extensively in the casting process; but to attribute the cause of these casting defects to the use of pure gold is unreasonable when we know that thousands of castings have been made with pure gold, under various casting conditions, without disconnection or constriction in the stem. Again, we must remember that casting golds may become very sluggish when they have been melted and recast many times, particularly if they have been overheated or contaminated. Hence, it may be difficult to heat them to the proper degree of fluidity for casting; or, in an oxidized condition, it may be impossible to determine visually when they have been heated sufficiently.

In attributing the cause of the discontinuity of metal to the use of certain types of blowpipes, there is an apparent disregard for the fact that casting golds with high fusing points cannot be adequately heated when blowpipes are defective and inefficient.

By the same token, to explain these casting anomalies by the use of cold molds or small sprues is to forget that, with all other conditions equal, a cold mold or a small sprue will require the metal to be heated to a higher degree than would be necessary for hot molds and large sprues. Thus, with a poor blowpipe, contaminated casting gold, a cold mold and an extremely small sprue, the chances are excellent for discontinuity of the metal in the sprue; yet the direct cause is insufficient heating of the casting metal beyond its fusing point.

It has frequently been stated that separation of sprues is caused by the use of certain types of casting machines. (Attention is again directed to the fact that this paper deals only with direct-pressure casting machines.) If it is assumed that the mechanical design of the machine allows sufficient and sustained pressure, the resulting incomplete castings should be attributed to the condition of the machine (and the flask) rather than to the type of machine. If the asbestos sealing pad of the machine is defective or the upper border of the casting flask is uneven, an air-tight seal is not insured. Hence, the pressure may be insufficient or not sufficiently sustained to complete the casting.

This treatise on the causes of discontinuity of metal in sprues during pressure-casting is not written with the idea of completeness or infallibility, but rather with the thought of stimulating interest in the subject to the end that the problems of the casting process may be ultimately solved. Criticisms and suggestions are, therefore, solicited.

FLUORINE IN RELATION TO BONE AND TOOTH DEVELOPMENT*

By FLOYD DeEDS, Ph.D., San Francisco, Calif.

FOR many years, a pathologic condition known as enamel dystrophy, or mottling of the enamel, has been of interest to the dental profession, especially in certain areas where the condition is endemic and involves a large percentage of the population. Within the last few years, interest in this pathologic condition has been intensified by the discovery that fluorine is the etiologic factor.

The history of chronic fluorine poisoning is an interesting chapter in the relationship of public health to chemical elements and compounds capable of inducing chronic intoxication. The time allotted to this discussion does not permit a complete review of the subject. Instead, mention will be made of a few of the main points of interest. For more detailed information, reference is made to the review published in *Medicine*.[1]

Fluorine is one of the most widely distributed elements. In the first mile of the earth's crust, it is said to rank twentieth. Not only is there a wide distribution of inorganic fluorine, but also, in vegetable tissues and in the bones and teeth of man and the lower animals, the element occurs as calcium fluoride in proportions ranging from traces up to 2 per cent, or even more. In view of the wide distribution of fluorine in inanimate nature, it is not surprising that it is found in many living forms. Its occurrence in the bones and teeth of man and the lower animals has led to the belief that fluorine plays some important biologic rôle.

It is entirely possible that the presence

*Presented at the Annual Meeting of the California State Dental Association, April 9, 1935.

*From the Bureau of Chemistry and Soils, United States Department of Agriculture, at the Department of Pharmacology, Stanford University School of Medicine.

1. DeEds, Floyd: Medicine, 12:1-60 (Feb.) 1933.

of fluorine in animal tissues is an expression of the inevitable tendency to establish a chemical equilibrium between the organism and its environment. The distribution of fluorine in the tissues may be explained on the basis of its chemical characteristics. The low solubility of the calcium salt accounts for its accumulation in the bones and teeth. Fluorine occurs in the mineral apatite in combination with phosphate. It is, therefore, not surprising that Gautier and Clausmann[2] found that the fluorine of the tissues is localized in a specific manner, and that fluorine accompanies the alkaline earth phosphates and increases with them.

age. By feeding rats an experimental diet in which care was taken to keep the fluorine content at a minimum, the following observations were made: Reproduction was unaffected; the fluorine content of the bones could be "reduced to between 6 and 25 parts per 1,000,000, and could be eliminated from the teeth, without showing any gross deleterious effect"; and no change was produced in the calcium to phosphorus ratio in the bones. This evidence supports the idea that fluorine plays no important useful biologic rôle.

On the contrary, there is an increasing volume of evidence of the injurious

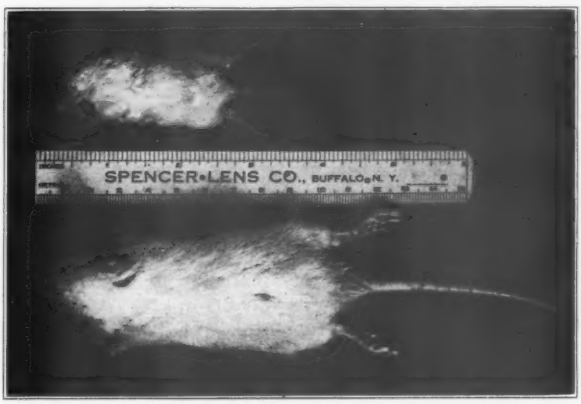

Fig. 1.—Litter mates showing inhibition of growth by 0.1 per cent sodium fluoride in diet.

Studies by Sharpless and McCollum[3] furnish information regarding the biologic rôle of fluorine. They found that young rats (aged from 16 to 18 days) contain little, if any, fluorine; whereas, adult rats have considerable fluorine in the bones and teeth, the amount varying with the diet fed and increasing with

effects of fluorine, especially the chronic intoxication resulting from the ingestion of minute amounts of fluorine over long periods of time. The studies conducted by Dr. Smith and her co-workers at the University of Arizona have shown that 1 part, and possibly 0.8 part of fluorine, per million parts of water will produce definite signs of enamel dystrophy in children born and reared in an endemic area. Such data enable us to calculate the approximate dosage of fluorine per

2. Gautier, A., and Clausmann, P.: Compt. Rend. de l'Acad. de Sc., 156:94, 1425, 1913.

3. Sharpless, G. R., and McCollum, E. V.: J. Nutrition, 6:163 (March) 1933.

unit of body weight per day capable of producing a definite degree of tooth injury in the majority of children. During the first six years of life, the body weight ranges from approximately 7 pounds at birth to about 40 pounds at the age of 6. The average weight during this period is about 25 pounds, or 12 kg. If it is assumed that the average daily water intake is 1 quart, or 1 liter, a fluorine content of 0.8 part per million parts water would mean a fluorine intake of 0.0008 gm. per day, which for 12 kg. of body weight would be 0.07 mg. per day per kilogram of body weight.

Fig. 2.—Overgrowth of rat incisor. The diet contained 0.05 per cent cryolite.

It is interesting to compare this value for the injurious fluorine dosage with the values that have been determined experimentally for lead and arsenic in the white rat. Lead acetate added to the food will check the growth and appetite of the white rat when a dosage of from 0.0007 to 0.1500 mg. per day per kilogram of body weight is administered. This wide dosage range is due to variation in susceptibility of the rats and to variation in the severity of the symptoms. Addition of arsenic trioxide to the food causes loss of body weight in the white rat when the dosage is from 0.0015 to 0.0050 mg. per kilogram of body weight per day. Such a comparison of toxicity data suggests that fluorine, lead and arsenic belong to the same group, as far as ability to cause some symptom of toxicity in minute dosage is concerned.

Thus far, the ability of fluorine to induce chronic intoxication when administered in minute amounts over long periods of time has been considered. Let us now pass on to the general actions of fluorine and its action on bones and teeth.

Fluorine, a general protoplasmic poison, exerts a strong inhibitory action on many enzymes. The more complex inorganic compounds containing fluorine are frequently toxic because of a direct action of the compound itself, or because of a conversion of the complex compound, as by hydrolysis, into simpler compounds, such as the simple fluorides. Similarly, many organic compounds containing fluorine are toxic because of a liberation of fluorine in the presence of protoplasm. Moreover, even in the absence of such disintegration of the organic molecule with liberation of fluorine, the presence of fluorine in the molecule often enhances the toxicity of an organic compound. It has been shown by Lehmann[4] that the introduction of fluorine into the side chain of aromatic compounds, such as toluene and m-toluidine, increased the toxicity to frogs.

The toxic effect of fluorine compounds on yeast has been studied by Effront[5] and by Arthus and Gavelle.[6] The use of antiseptics, especially fluorine, in distilleries has been reviewed by Cluss.[7] Weh-

4. Lehmann, F.: Arch. f. Exper. Path. u. Pharmakol., 130:250, 1928.

5. Effront, J.: 1891, J. Chem. Soc., A. 1532, 1891; A. 905, 1892; A. II, 425, 1894.

6. Arthus and Gavelle: Compt. Rend. Soc. de Biol., 55:1481, 1903.

7. Cluss, A.: J. Soc. Chem. Ind., 13:535, 1894.

mer[8] has shown that the use of flourine compounds, particularly hydrofluoric and hydrofluosilicic acid, and their salts, prevents the growth of saprophytic bacteria and decay-producing organisms in wood. These points have a practical bearing on the public health because of the potential sources of fluorine toxicity for man.

The toxic effect of fluorides is manifested on many enzymes, those organic catalysts that may be separated from living, organized protoplasm. Amberg and Loevenhart[9] have demonstrated the inhibitory effect of fluorides in high dilution on lipase. Clifford[10] has shown that the enzymatic clotting of milk is inhibited by the addition of the fluoride of sodium, potassium or lithium. The inhibition of coagulation occurs suddenly and at a definite molarity of added fluoride. A difference of 0.0036 molar changes the time of clotting, which usually occurs in from five to thirteen minutes, to an absence of clotting in from four to six hours. The toxic effects of fluorine on enzymes suggest the possibility of an interference with metabolism and with the enzymatic processes associated with normal bone and tooth formation.

It has been shown in our laboratory[11] that fourteen parts of fluorine per million parts of diet will produce a noticeable degree of bleaching of the incisor teeth of the albino rat, regardless of whether the fluorine is added to the diet in the form of sodium fluoride, sodium fluosilicate, barium fluosilicate or sodium aluminum fluoride (cryolite). This effect occurs in spite of the marked differences in water solubility of these compounds. Less delicate criteria of toxicity, such as inhibition of growth, indicate that the more soluble fluorides are the more toxic. Figure 1 shows the marked inhibition of growth caused by the addition of 0.1 per cent sodium fluoride in the diet for a period of twenty-four days.

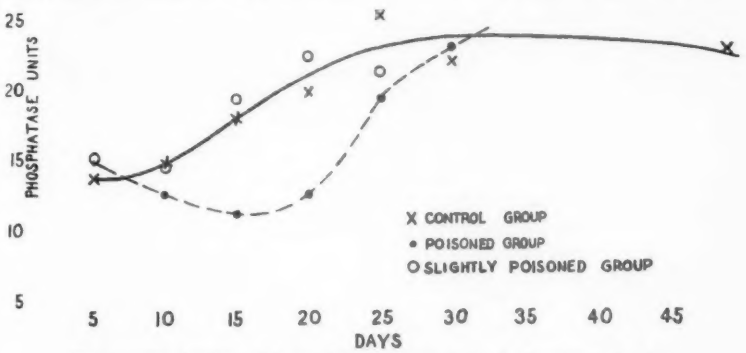

Fig. 3.—Diminution of bone phosphatase activity in fluorine poisoning.

In addition to bleaching of the incisors, other effects are induced in the rat by ingestion of fluorine. The teeth are more subject to breakage. As a result of loosening in the sockets, the normal

8. Wehmer, C.: Chem. Ztschr., 38:114, 122.
9. Amberg, S., and Loevenhart, A. S.: J. Biol. Chem., 4:149, 1908.
10. Clifford, W. M.: Biochem. J., 22:1128, 1928.
11. DeEds, Floyd, and Thomas, J. O.: Proc. Soc. Exper. Biol. & Med., 31:824-825 (April) 1934.

apposition of the incisors may be prevented, marked overgrowth resulting. (Fig. 2.) The rat shown in Figure 2 had been on a diet containing 0.05 per cent cryolite for three months, although pronounced bleaching of the incisors and definite overgrowth was evident at the end of six weeks.

When examined at necropsy, the ribs of fluorine-poisoned rats are seen to be whiter, thinner and more fragile than those of control rats. Alteration in the jaw bones caused by chronic fluorine poisoning has been the subject of investigation by W. Pachaly.[12] By vital staining with alizarin, he demonstrated the interference with calcium deposition in the maxillary bone.

Biochemical evidence obtained in our laboratory has given information with regard both to bone injury produced by chronic fluorine poisoning and to the mechanism of the injury. The work of R. Robinson[13] has definitely established the significance of phosphoric esters in metabolism and the importance of the enzyme phosphatase in hydrolyzing these esters, the liberated phosphate ion being utilized in the process of calcification. Because of the action of fluorine compounds on enzymes in general, it seemed logical to investigate the action of fluorine on the enzyme phosphatase.

It has been claimed by P. H. Phillips[14] that chronic fluorine poisoning of heifers and swine is characterized by an increase in plasma phosphatase. Attempts in this laboratory to study plasma phosphatase in rats failed to yield any conclusive results. Therefore, attention was turned to a study of bone phosphatase.

When the bone phosphatase of fluorine-fed rats was compared with that of

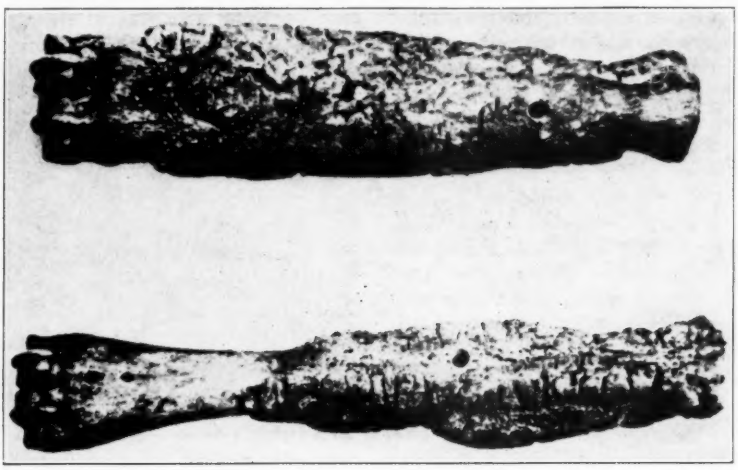

Fig. 4.—Exostosis in cattle produced by presence of volcanic ash on vegetation in Iceland. (Figures 4 and 5 from Nordisk medicinsk tidskrift, Aug. 25, 1934.)

12. Pachaly, W.: Arch. f. Exper. Path. u. Pharmakol., 166:1, 1932.

13. Robinson, R.: Biochem. J., 17:286, 1923; Ergebnisse der Enzymforschung, 1:280, 1932.

14. Phillips, P. H.: Science, 76:239, 1932.

control rats, it was found that fluorine toxicity was associated with a decrease in bone phosphatase activity up to age limits of about 30 days. This relationship exists only under strictly controlled conditions.

The control and experimental rats must be obtained from litters of the same size, and within 1 or 2 days of the same age. Two rats having litters within one or two days of each other were selected, and the larger litter was reduced in number to that of the smaller. Within one day after delivery of the litters, one of the mother rats was placed on a diet containing fluorine, the other mother rat being allowed to remain on the normal control diet. Up to the time of weaning, the only source of fluorine for the young rats in the experimental group was the mother's milk.

At five-day intervals, one control rat and one experimental rat were killed, and, after muscle and tendon tissues were carefully removed, determinations of bone phosphatase activity were made on the combined femur, fibula and tibia. Figure 3 illustrates the correlation between bone phosphatase activity and fluorine poisoning.

In addition to this correlation, it was found that the extent to which the bone phosphatase activity of the experimental rats deviated from that of the controls agreed roughly with the deviation of the growth curve from the normal. The more the experimental growth curve approximated a normal growth curve, the less the deviation in bone phosphatase activity.

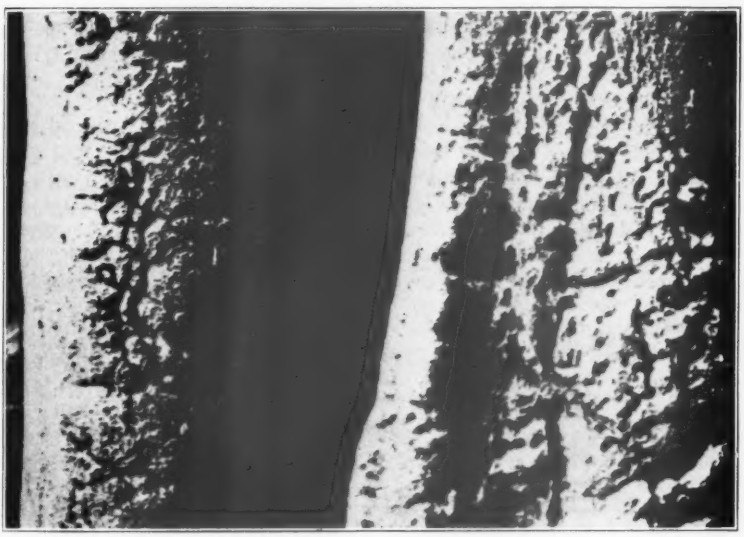

Fig. 5.—Exostosis produced experimentally in sheep by addition of sodium fluoride to diet.

To what extent can these results obtained *in vivo* be duplicated *in vitro?* To answer this question, and to obtain further information on the mechanism of fluorine poisoning, the ability of an active bone phosphatase preparation to hydrolyze sodium glycerophosphate in the

presence of varying molar concentrations of sodium fluoride was studied. It was found that sodium fluoride decreased the activity of bone phosphatase and that the inhibition was roughly proportional to the fluoride concentration and could be demonstrated in a concentration as low as one two-hundredth molar.

Fluorine toxicity is far from being confined to modern times. Recently, attention was drawn to an article entitled "Fluorosis in Sheep in Iceland After Volcanic Eruptions,"[15] giving evidence of fluorine poisoning in Iceland, 1,000 years ago. The author shows that the sheep and the cattle of Iceland have been periodically afflicted with a pecular pathologic condition of the bones after a volcanic eruption. Figure 4 shows the pecular spongy bone growth over the normal bone in a specimen on exhibit in the museum at Copenhagen, Denmark. Figure 5 shows the apparently identical formation induced by that author by feeding sodium fluoride to sheep in a dose of 15 mg. of sodium fluoride per kilogram of body weight.

In the investigations of Taylor,[16] Reed and Huffman[17] and Phillips, Hart and Bohstedt,[18] exostosis of the long bones was produced in dairy cows by feeding diets containing fluorine.

CONCLUSION

Fluorine is one of the widely distributed elements. It occurs in many foods in small amounts. It occurs in many water supplies, and, in certain regions, its presence in the water is the cause of mottling of the enamel of the teeth. Fluorine is a general protoplasmic poison, but the most important symptoms of chronic fluorine poisoning known at present are mottling of the teeth and interference with bone formation.

It is virtually impossible to avoid a small fluorine intake, just as it is virtually impossible to avoid a small lead intake, but when the threshold value is exceeded, as it is in drinking water containing one or more parts of fluorine per 1,000,000, detectable signs of toxicity appear.

15. Nord. med. tidskr., 8:1093-1102 (Aug. 28) 1934.

16. Taylor, G. E. T.: Mich. Agr. Exper. Sta., Quart. Bull., 2, 1929, p. 101.

17. Reed, O. E., and Huffman, C. F.: Mich. Agr. Exper. Sta., Tech. Bull., 1930, p. 105.

18. Phillips, P. H.; Hart, E. B., and Bohstedt, G.: Univ. Wisconsin Agr. Exper. Sta., Res. Bull., 1934, p. 123.

DENTISTRY IN RELATION TO THE BLOOD DYSCRASIAS*

By WILLIAM P. MURPHY, M.D., Boston, Mass.

THE keynote to successful progress in the sciences today is cooperation, within the boundaries of each scientific field and sufficient to allow each member of the group to receive the benefits of the education and constructive thought possible only through strong organization, and between the several organized scientific groups, in order that each may benefit from the others.

This is particularly true in the fields of dentistry and medicine. With the ever increasing intensive study of specific problems, it becomes each year more and more difficult for any of us to know all that there is to know about our own subject, so that we must often look to the specialist for advice in his field of choice. The physician consults with the dentist when a problem in dental hygiene is to be considered and, in like manner, the dentist may find it important to understand his patient's general physical difficulties before carrying out a program of dental reconstruction.

Dental clinics, with visiting dentist and house officers, are now a part of hospital organization. Consultations concerning dental problems are as regularly carried out as are consultations concerning other specialized problems. Through this cooperation not only does the patient of today receive the best possible advice and the most intelligent treatment of all of his physical and mental difficulties, but also the physician and the dentist are able to study and to determine the influence of one disease condition on another.

The close relationship between the various chronic illnesses and the condition of the teeth and mouth is now generally recognized. How frequent it is to find a bad set of teeth in a patient whose illness is associated with or dependent on some specific or complicated nutritional disturbance! Just when to consider the teeth as a factor in these disturbances and when to consider the bad state of the teeth as a part of the general illness caused by the disturbed nutritional factor can be determined only by study of each individual case. It is then not always possible to differentiate between cause and effect, and no doubt at times the two factors combine in a single rôle of cause and again of effect.

This is well illustrated by the patient with arthritis. Our present day concept of the disease arthritis, at least of one type, is that there are metabolic changes associated with an inability to utilize certain food substances, notably the carbohydrates, and an inadequate supply or utilization of others, notably vitamins and calcium, and, as a result, nutritional changes occur which result in the general disease state known as arthritis. The condition is particularly manifest in the

*From the Medical Service of the Peter Bent Brigham Hospital.

*Read at the Twenty-First Annual Meeting of the Massachusetts Dental Society, Boston, April 29, 1935.

joints and, because of an abnormal state of nutrition, there may occur disease of the teeth. As time goes on, alveolar abscesses may appear secondarily to the changes which have developed in the mouth. Then the teeth become the causative or at least aggravating factor in the disease condition, and progress toward recovery is delayed until the infection is eradicated. By this, I do not mean to say that I believe in the promiscuous removal of teeth as a part of the treatment of any chronic disease. There are far too many unnecessarily toothless mouths today because of failure to evaluate properly the rôle of the teeth as cause or effect of the disease.

It is not my intention to attempt to differentiate between the rôle of cause and effect of pathologic states of dentition and the various pathologic states which may be present in such conditions as diabetes, arthritis and anemia, but rather to attempt to point out some ways in which the dentist and the physician must cooperate in the management of illness and, in particular, in the management of a few of the blood dyscrasias.

Teeth are necessary for the proper mastication of food. An inability to masticate food may lead either to avoidance of a properly balanced diet or, because of inadequate breaking up and mixing with the various digestive juices, to improper assimilation.

This point may best be illustrated by the experience of two of my patients.

The first, a woman now in the late fifties, is a patient in the blood clinic at the Peter Bent Brigham Hospital. During her youth, she had so many ulcers in the mouth that chewing of vegetables and meat was difficult. In consequence, she almost never ate either, but lived almost solely on a liquid or soft diet. She then developed a rather severe grade of anemia, probably of a simple or secondary sort and, as the years went by, with this a sore tongue. The teeth were blamed for this and extracted, but as improvement did not occur, she was unable to use her false plates, as the gums also became sore. She continued to live on a diet of bread and tea and first came to my attention as presenting a case of pernicious anemia. Today, with the more intimate knowledge of anemia and methods for its control, the anemia would have been controlled and with it the soreness of the mouth, so that the teeth would have been saved. She might even have avoided the development of pernicious anemia had she been able to eat properly.

The second patient, an elderly woman, entered the ward of the hospital suffering from a painful ulceration of the right buccal mucous membrane, associated with a marked decrease in the white blood cell count, a condition of chronic granulocytopenia, or agranulocytic angina. This was associated with arthritis. During her stay in the hospital, in spite of improvement in the ulceration, she refused to take any food from her tray except that in soft or liquid form. One morning, in talking with me alone, she confided that she did not eat because she could not wear her false teeth owing to the painful ulceration. We had supplied her only with the regular house diet, which was too coarse for her to masticate.

But to come to specific blood disturbances, let us first consider leukemia, a condition in which there is disturbance in white blood cell formation, usually with a marked increase in one or another type of cell. These patients have a notably low resistance to infection, and alveolar abscess occurs commonly during the course of the disease, or may often be the first definite symptom. Now to remove such an abscessed tooth before treatment of the blood condition may simply cause a marked spread of infection, an otherwise chronic condition, which may be controlled, being changed into an acute one for which even palliative treatment is impossible. On the other hand, the presence of the infection makes control

of the blood condition difficult. It is then wise perhaps to attempt to drain such an abscess until such time as removal of the tooth may be undertaken with less danger to the patient.

In the same condition, it may be that the dentist will first encounter the patient because of the fact that the abscess develops before there are other outstanding symptoms. It may be well to refer the patient with an abscess developing acutely with fever, malaise and possibly pallor and a tendency to bleed about the gums to the physician for a blood analysis before undertaking extraction.

Purpura hemorrhagica is a condition in which there is an abnormal tendency to bleed from mucous surfaces and to develop black and blue spots not caused by an injury. This condition may occur with leukemia and other blood disturbances or as a separate disease. Here again, extraction is to be avoided because of the tendency to unusual hemorrhage after any trauma. During the course of treatment, it may be important to clean the teeth at the gum margins and to improve the condition of the gums as far as possible. For this, we must call on the skill of the dentist.

Perhaps the latest and most fashionable disease of the blood which one may have today is a condition variously known as agranulocytosis, agranulocytic angina or acute granulocytopenia. This condition is one in which certain of the white blood cells become markedly decreased in number, with consequent lowered resistance to infection and the development of painful abscesses or necrosing areas in the mouth or elsewhere. It is often preceded or accompanied by alveolar abscesses. The course of the disease is rapid, and until recently, with the advent of better forms of treatment, has been fatal in from 80 to 100 per cent of instances. As opposed to the more conservative treatment in leukemia, drainage of an abscess or extraction of the offending tooth must accompany specific therapy in order to obtain satisfactory results, for the duration of the illness may be only a matter of days. It is important to recognize the condition without delay and before extraction or protracted dental treatment is carried out so that specific therapy may also be instituted. An example of this situation is that of an elderly woman whom I saw in consultation several years ago. Her illness began in the usual manner, with severe headache, high fever, sore throat, generalized aching and soreness of the gums. She consulted her physician and dentist, who both believed the condition to be the result of alveolar abscesses which were present. A large number of teeth were extracted, after which she developed extensive ulcerations with necrosis at the site of the extractions. Her condition grew rapidly worse and death ensued within forty-eight hours. An examination of the blood, with a leukocyte count, would have made the diagnosis clear.

Now let us consider the anemias, which may be discussed as a group, possibly of greater importance than the foregoing, principally because of their much more frequent occurrence. Although, in the anemias, we rarely are called on to deal with the acute and imminent situations which have been described, there are several important points for the dentist and physician to consider together.

In the first place, the occurrence of dental disease in association with anemia is common. Whether such disturbances are more common in association with anemia than in the population at large, I am not prepared to say. We must realize that the blood supply to the teeth and gums will be altered as it is to other parts of the body and there may be definite nu-

tritional disturbances present either as causative factors in the anemia or in association with it. It may, therefore, be necessary to rectify these nutritional difficulties as well as the anemia before success in treatment will be possible. Dental caries, pyorrhea, tendency to bleed along the gum margins and alveolar abscesses are all encountered in these patients.

On the other hand, it is important, from the physician's point of view, to clear up any existing infections in order to carry out successfully the treatment of the anemia. One of my patients with secondary or hypochromic anemia was treated without adequate improvement for a considerable time. Finally, it became possible gradually to extract her few remaining teeth, all of which were abscessed, and thereafter improvement was rapid. No doubt, this was the result not only of elimination of the chronic infection, but also of the fact that she soon became able to ingest a more satisfactory diet. As any infection, either acute or chronic, will hinder blood formation, any known focus must be eliminated or complete success will not be possible.

I have emphasized the importance of clearing up the infections present in anemic patients. I wish to call attention particularly to the importance of extreme care in the handling of patients with pernicious anemia. These patients are very easily disturbed by any unusual circumstance, such as fright, worry and surgical procedure, and may as a result show a sudden and often marked drop in blood count and perhaps the beginning of nerve disturbances, which are the most difficult features of the disease to control. One of my patients, whose blood count had been satisfactory, went to her dentist for the extraction of an abscessed tooth, without telling me of it. Although it was a simple extraction, without undue trauma, she came to me a few days later feeling very miserable, her blood count showing a drop of about 1,500,000 cells from what it had been just previous to the extraction. In such a case, the patient should have been prepared by an increased intake of liver, so easily accomplished by means of the injection of the concentrated solution of liver extract now available. Because of this and other similar experiences it seems advisable in pernicious anemia to extract not more than one tooth at a sitting.

Because of the frequent occurrence of a soreness of the tongue or mouth as one of the first symptoms of pernicious anemia, the patient may first consult his dentist. Several of my patients have been referred to me by their dentist for study during the early stage of the disease because of the finding of a sore tongue not logically explained on the basis of altered dentition.

311 Beacon Street.

DETERMINATIONS REGARDING THE STRENGTH OF DENTURE MATERIALS: VULCANITE*

By HORTON D. KIMBALL, D.D.S., D.D.Sc., Detroit, Mich.

VULCANITE is perhaps one of the most abused and least understood materials in the practice of dentistry today. Because the technic of manipulation is relatively simple, many have grown careless in their treatment of it.

Most denture cases are flasked and packed in an uncertain fashion, and are then vulcanized for a more or less indefinite time and temperature.

Some have noted that certain vulcanizing technics yield a vulcanite which appears stronger than that produced by other methods. There are practically no data to show how much the increase in strength might be. Neither are there any specifications set up for the strength of vulcanite.

PURPOSE

It has been the object of these investigations to aid in developing tests that would enable one to determine the true strength and nature of vulcanite as it is used in prosthetic dentistry.

A comparative study was made of the strength of vulcanite as affected by several different methods of curing.

With these data to serve as a more or less arbitrary standard or criterion, it is intended, in subsequent investigations, to test and compare several different kinds of vulcanite, with the object of finding the best cure for each one. There will also be a test and comparison made of other denture materials.

COMMENT

This work was intended to be of as practical a nature as possible and, for this reason, the vulcanite specimens were prepared in a manner as much like that used in making dentures as possible. Only one kind of vulcanite was used in this series of experiments, in order to simplify the whole procedure. The dental rubber was the brown "English-base" type.

The vulcanizer was of the horizontal type. Temperatures were recorded by means of a pressure gage at the back of the vulcanizer and a bulb thermometer mounted in the door. Accurate determinations of temperatures were assured in the following manner: A thermocouple was previously designed and inserted in the middle of the vulcanizing chamber. When the temperatures recorded by this were compared with those shown on the pressure gage and thermometer, they were found to check closely. The thermocouple was next placed into the middle of the flask full of plaster, and a comparison was made between the temperature inside the flask and that inside the vulcanizer. The full description and the data on this experiment are contained in another paper.

It was found that there was a ten minute "lag" between the temperature recorded by the thermometer and that actually in the vulcanizer. There was, in turn,

*Read before the Full Denture Section of the Detroit Clinic Club, May 24, 1935.

*Survey undertaken in connection with work with R. H. Kingery, B.S., D.D.S., head of the Prosthetics Department of the University of Michigan Dental School.

roughly, a thirty minute "lag" between that of the interior of the flask and the vulcanizer itself. In other words, within thirty minutes after the vulcanizer had reached a certain temperature, the interior of the flask registered the same temperature. This time varied somewhat under different conditions. Thus, an accurate knowledge was obtained of the temperatures under which the rubber was vulcanized.

The vulcanizing procedure was as follows: The regulator valve was set at 320 F. The water was boiling in the vulcanizer as the flasks were inserted. When the pressure gage showed 15 pounds +, the blow-off valve was opened to allow the air to escape. After the pressure had

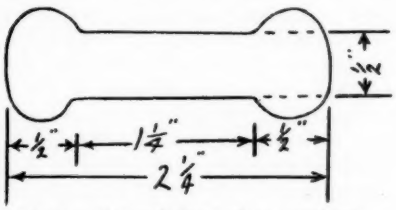

Fig. 1.—Size and shape of test specimens.

dropped to 10 pounds + (roughly, in ten to fifteen seconds), the valve was closed. In forty minutes after the valve was closed, the desired curing temperature was reached, and the time of the vulcanizing process was taken as beginning at that point. When the vulcanizing time was up, the gas was shut off and the vulcanizer allowed to set overnight before it was opened, or otherwise disturbed. In this manner, all conditions, except actual variation of the cure, were kept constant.

In establishing the cures to be used, it was felt that as 320 F. was perhaps the most commonly used temperature for vulcanizing, it would be acceptable as the standard vulcanizing temperature in preparing the test specimens. This temperature was kept constant and the cure itself was varied by changing the length of time that the strips were cured.

Three different curing times were used: one, two and three hours respectively. This technic produced vulcanite specimens which might be called undercured, average cured and overcured. In all cases, it took forty minutes to pass from 225 to 320 F.

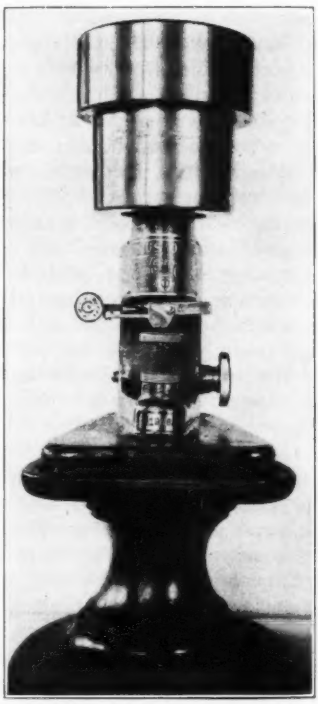

Fig. 2.—Hardness testing machine, designed for testing soft materials.

The various cures may be tabulated as follows: Cure 1: Temperature allowed to remain at 320 for one hour; Cure 2: Temperature allowed to remain at 320 for two hours; Cure 3: Temperature allowed to remain at 320 for three hours.

It was stated earlier in this paper that

approximately thirty minutes was required for the temperature inside the flask to equal that in the steam chamber of the vulcanizer. It is, therefore, interesting to note that the specimens were not vulcanized at 320 F. for the entire curing time. Thus, under Cure 1, vulcanization at 320 F. was continued for approximately thirty minutes only; under Cure 2 for one and one-half hours and under Cure 3 for two and one-half hours.

Metal patterns were used to prepare molds for the vulcanite specimens. Three of them were soldered to the reverse side of the bottom half of a spring-clamp plate-flask. After the patterns were oiled slightly, the middle half of another flask was inserted in position and plaster was carefully vibrated into this half around the metal patterns. After this had hardened, the patterns were freed by tapping the base gently. The bottom half of this second flask was filled with plaster and a glass slab pressed down firmly over it. The plaster was mixed in the ratio of 2 parts plaster (by weight) to 1 part water. It was spatulated mechanically and vibrated into place. With this procedure, plaster molds were obtained which were uniform in all respects. They were perfectly smooth and free from air bubbles.

In most of the other work done on the strength of denture materials, specimens have been prepared in metal molds. It was found early in this present study that contact of metal with vulcanite during the curing process greatly affected its strength. As most dentures in practice are cured against plaster, it was felt that tests made on specimens prepared in a like manner would have a more practical value.

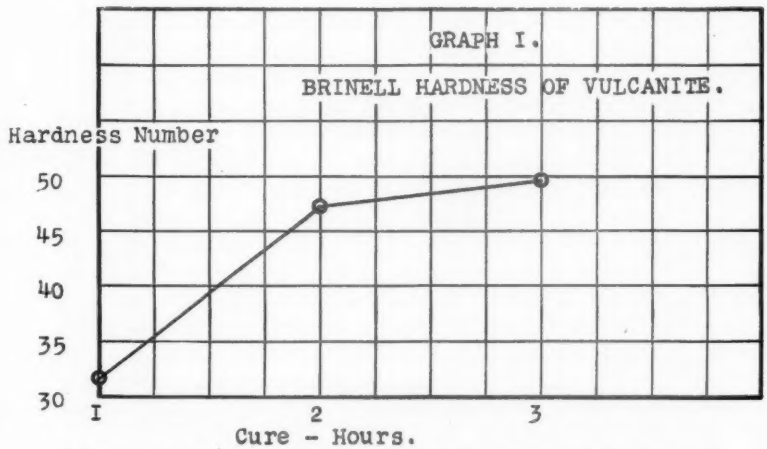

Fig. 3.—Graph showing relation between various curves as regards hardness.

The patterns were designed as shown in Figure 1. This shape facilitated the application of the tensile strength test to certain specimens. In the application of other tests, the "ears" of the specimens were carefully finished down until the sides were parallel.

The patterns are 2 mm., or about one twelfth inch, thick. In the past, strength tests on denture materials have dealt with

specimens averaging one quarter to one half inch in thickness. There are various reasons for this practice.

In the first place, it was believed that a smaller margin of experimental error would be present in making tests on thick specimens than on thin ones. Again, the testing machinery used was not sufficiently delicate to measure strength variations of thinner specimens accurately. It was felt in the beginning of these investigations that if strength tests could be made on specimens that were the approximate thickness of the average denture palate, they would be of far greater value in determining the true nature and strength of vulcanite than those tests made on thicker specimens. It is obvious that certain physical properties possessed by a thick piece of vulcanite may be markedly different from those of a thin one.

With this in mind, much care and thought was given to the various kinds of machines to be used in performing these tests. It was even found necessary in some instances to design and have built certain special testing machines. These will be discussed more fully under their proper headings.

Suffice it to say that a way was found to make accurate strength determinations on a thin piece of vulcanite.

It is well known that rubber shrinks during the curing process. Owing, perhaps, to this inherent property, it was found impossible to prepare test strips that would always be exactly uniform in size. The specimens were all found to have one surface slightly roughened and irregular, and containing small depressions or pits. This rough face was invariably on the side where the two halves of the flask separated.

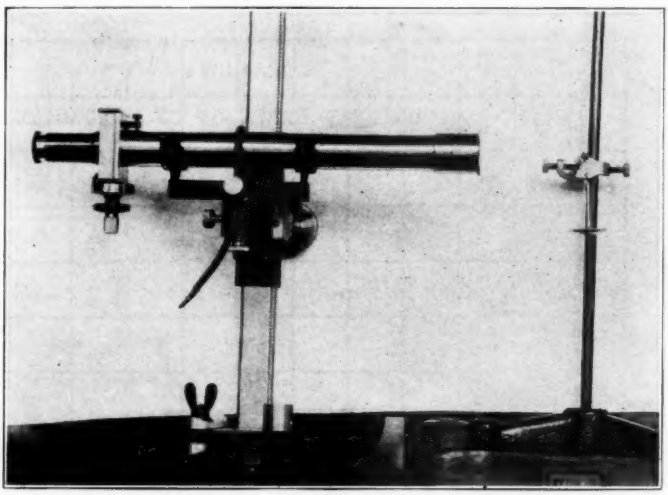

Fig. 4.—Apparatus for measuring modulus of elasticity.

In certain tests, the specimens were sanded down slightly to remove this irregular surface. As far as could be determined, the sanding operation did not affect the strength to any appreciable extent.

The strength of a material may be con-

sidered as the action of the material in resisting loads and other forces which come upon it. A text on materials of construction[1] gives a discussion of the general nature of deformation and stress.

When a solid body is acted on by external forces, two results are usually produced: (1) the body is deformed to a greater or less extent and (2) there are developed within the body internal resisting forces that balance the external applied forces. The deformation is called the strain and the internal forces acting between consecutive particles are called stresses.

There are many various kinds of stress produced in a body. On the basis of arrangement and direction of the external forces, these may be: (1) tensile stresses, (2) compressive stresses, (3) shearing stresses, (4) bending stresses, (5) torsional stresses and (6) various components of the foregoing stresses.

Materials behave differently in their reaction to stress. Some of these differences are indicated by the following terms: elastic, ductile, brittle, stiff, tough, malleable and hard.

It is well, then, to consider beforehand the type of stresses which the material in question will have to endure when in practical use and to which it should offer the greatest resistance.

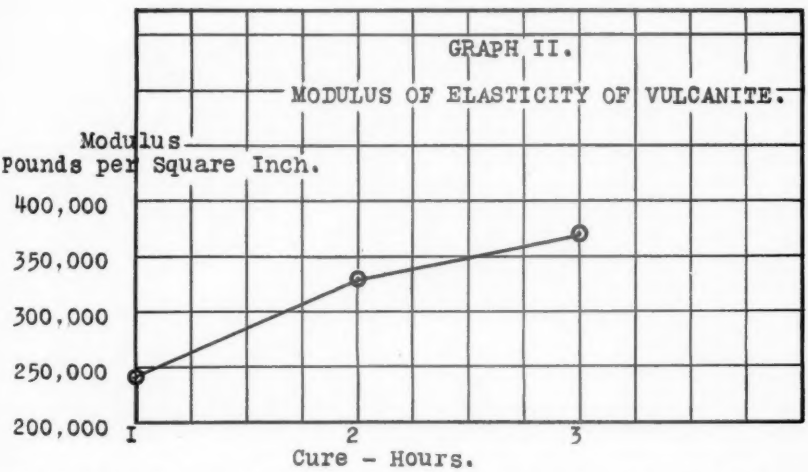

Fig. 5.—Graph showing relation between various curves as regards modulus of elasticity.

It is generally agreed that vulcanite in a denture should be as hard as possible; should be tough, yet also elastic and resilient to a degree, and should not be too brittle.

With these qualities in mind, the following strength determinations were made and recorded: (1) hardness—(Brinell), (2) modulus of elasticity, (3) tensile strength, (4) flexural strength (transverse strength), (5) impact strength and (6) flexure fatigue. All tests

1. Johnson, J. B.: Materials of Construction (Rewritten by M. O. Withey and J. Aston, edited by F. E. Turneaure), New York City: John Wiley & Sons, 1930, p. 1.

were made at room temperature of about 20 C. (68 F.)

PROCEDURE

1. *Hardness.*—Hard materials offer high resistance to scratching or denting. They are not necessarily of great strength. Thus, glass is hard, but also brittle.

Barber,[2] using a Vicker's machine, obtained hardness values which he considered as only tentative and comparative. He believed that vulcanite was too soft to give satisfactory hardness figures.

In these investigations, it was found that definite data could be obtained by using a machine of the Brinell type. This machine was an Olsen Last Word Hardness Tester No. 1. It is designed for testing soft materials, which cannot be satisfactorily tested by applying the standard Brinell loads or under the standard Brinell conditions. (Fig. 2.)

In this instrument, a sixteenth inch steel ball is used, applying a load of 12.61 kg., the load bearing the same relation to the sixteenth inch ball that the 500 kg. load bears to the 10 mm. ball in the standard Brinell test. DeVries,[3] of the U. S. Bureau of standards, has found that a linear relationship exists between the load and depth of indentation for loads of less than 3,000 pounds. A "Last Word" indicator was mounted on the hardness tester and was so arranged as to record the depth of penetration directly.

In testing, the anvil with the recording instrument is brought to bear directly upon the specimen. The depth recording dial is set at zero. The weight or load is then permitted to rest gradually on the specimen through the sixteenth inch steel ball. When the load has rested upon the specimen for one minute,[4] the former is removed and the reading of the instrument taken. This accurate measurement of the depth of impression, when referred to a special table, will give a hardness number based on the weight applied, the diameter of the ball

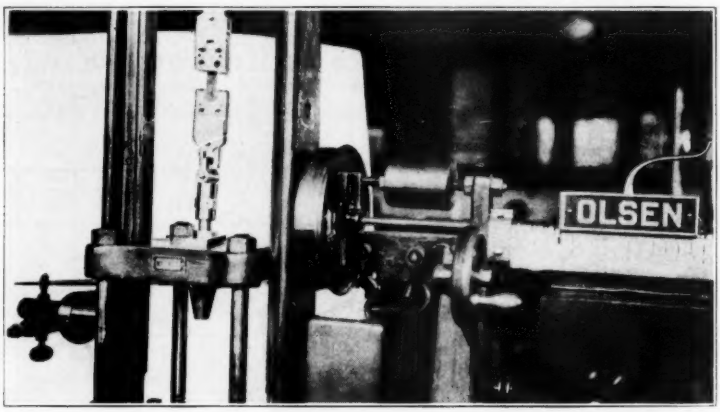

Fig. 6.—Machine for testing tensile strength, using specially designed grips.

2. Barber, Ronald: Some of the Newer Denture Materials, J.A.D.A., 21:1969 (Nov.) 1934.

3. Footnote 1, p. 25.

4. Circular of Bureau of Standards No. 38. Testing of Rubber Goods, Ed. 4, Sept. 28, 1921, p. 91.

used and the measurement of the depth of the depression. In this table, the higher the hardness number, the harder the material.

With the hardness machine, it was possible to obtain a hardness reading of the samples just as they came from the flasks.

Other hardness tests were also attempted: scleroscope, Rockwell and the diamond point scratch test. The best results were obtained with the Baby Brinell type machine.

Hardness tests were made on vulcanite of the three different cures. It was found that vulcanite prepared as outlined in Cure 1 was decidedly soft. It was

TABLE 1.—BRINELL HARDNESS OF VULCANITE*

Cure	Brinell Hardness Numbers Range	Average
1	30.1 — 33.3	31.83
2	44.4 — 46.8	45.45
3	48.6 — 50.6	49.59

*Using an Olsen Last-Word Hardness Tester No. 1; load, 12.61 kg.; steel ball diameter, one sixteenth inch; duration of load, one minute.

"undervulcanized" and was not constant in its hardness, nor softness, some parts of the same specimen occasionally being considerably harder than other parts.

Samples vulcanized as shown in Cure 2 were much harder. Their hardness number averaged about 30 per cent higher than that of specimens from Cure 1, and they were uniformly constant in their hardness.

With Cure 3, the increase in hardness was not nearly so great as it was between Cures 1 and 2. In this case, the specimens averaged only 9 per cent harder than those of Cure 2.

Table 1 presents a comparison of the average hardness number of the three cures, as well as the minimum and maximum hardness, or range, for each one.

Figure 3 illustrates the progressive increase in hardness as the curing time changes from one to three hours.

2. *Modulus of Elasticity.*—As a means of measuring and comparing the relative stiffness and flexibility of vulcanite samples, a determination of the modulus of elasticity was made. The higher the modulus, the stiffer the material. The stiffer the material, generally speaking, the higher its elastic limit.

A standard text on the strength of materials[5] states that all bodies suffer strain when subjected to stress, recovering their

TABLE 2.—MODULUS OF ELASTICITY OF VULCANITE (YOUNG'S MODULUS)

Cure	Modulus of Elasticity Range	Pounds per Square Inch Average
1	223,700 — 260,600	242,150
2	322,100 — 329,800	325,900
3	368,300 — 374,000	371,150

original form more or less completely when the stress is removed. Bodies which return to their original dimensions after enduring stresses are elastic; those that are permanently strained by very small stresses are plastic. One means of determining the elasticity of a material is by the ratio of unit stress to unit strain, within its elastic limit. The elastic limit is the maximum unit stress which can be imposed on a body without causing permanent strain or deformation. This ratio of stress to strain, known as "Hooke's law," is generally termed the modulus of elasticity.

Bending stresses are those produced by external forces that give rise to bending

5. Footnote 1, p. 14.

moments. The resulting stresses are compressive on one side of a neutral plane and tensile on the other side. The moduli of tension and compression are usually equal. The modulus for either direct stress is known as Young's modulus, and is denoted by the letter E.

A simple apparatus for measuring this modulus is described by Peyton and Moore[6] (Fig. 4): A short range telescope, equipped with cross-hairs was mounted on a rigidly supported upright rod. The rod was graduated in millimeters and equipped with a vernier that enabled accurate reading to 0.1 mm. (0.0039 inches).

The method of measuring consisted in fastening one end of a strip of vulcanite tightly in a clamp opposite the end of the telescope. The cross-hairs were focused on a given point 1 inch from the clamp. Various weights from 100 to 500 gm. were added to the strip at a distance of 1 inch from the point where it was held in the clamp. These applied weights caused displacement of the vulcanite strip, this displacement being measured by adjusting the telescope until the cross-hairs were once more focused on the given point.

Supporting the strip at one end and applying the load at the other in this manner produces a simple cantilever beam with the load on the free end.

A standard text on the strength of materials[7] gives the formula for deflection in this type beam as:

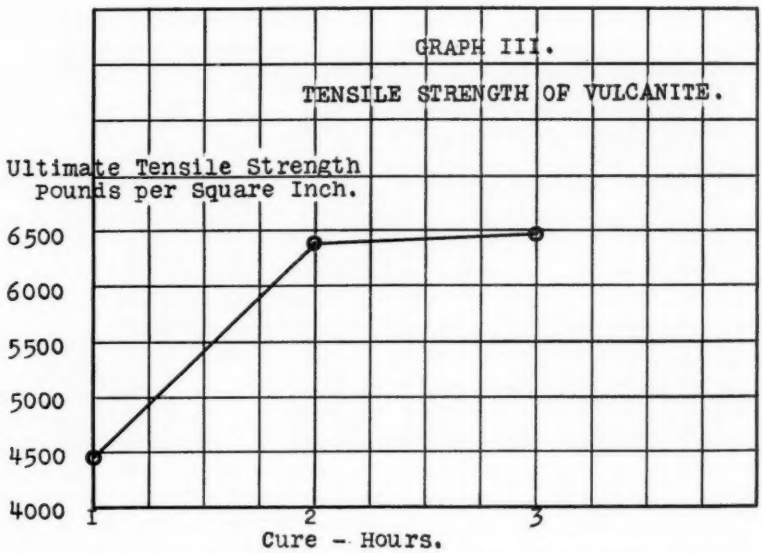

Fig. 7.—Graph showing relation between various curves as regards tensile strength.

6. Peyton, F. A., and Moore, G. R.: Flexibility Studies on Gold Alloy Wires and Orthodontic Appliances, Internat. J. Orthodontia, 19:799 (Aug.), 903 (Sept.) 1933.

7. Boyd, J. E.: Strength of Materials, New York City: McGraw-Hill Book Company, 1924, p. 147.

$$y=\frac{Pl^3}{3EI}$$

where y=displacement in inches, p=load in pounds, l=length of beam (or strip), E=modulus of elasticity (to be calculated) and I=moment of inertia, which is calculated from the formula:

$$I=\frac{bd^3}{12}$$

where b=width of beam (strip) in inches (at clamp end) and d=thickness in inches (at clamp end).

E is the only unknown in the foregoing formula which may be then converted to:

$$E=\frac{Pl^3}{3yI}$$

This formula may readily be applied to the measurements obtained in this test and E thereby calculated, by using the logarithmic functions of the numbers.

It was found from this test that strips prepared as outlined in Cure 1 had a very low modulus of elasticity, and were exceedingly flexible. Loads much over 400 gm. bent the strips over 2 mm. and produced a permanent bend, or distortion. Thus, the elastic limit is here noted to be 2 mm.

Strips prepared as outlined in Cure 2 had an average modulus about 25 per cent greater than those of Cure 1. They were far stiffer, and would take a load of nearly 500 gm. without permanent distortion, although, here again, when the strip was bent over 2 mm., permanent distortion occurred.

With Cure 3, the specimens proved only slightly stiffer and averaged but 13 per cent higher in their moduli of elasticity than those of Cure 2. A bend of much more than 2 mm. still produced permanent distortion.

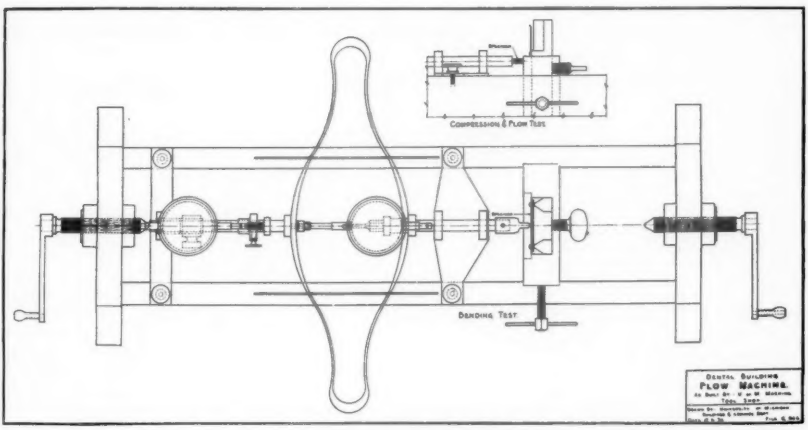

Fig. 8.—Machine for measuring flexural strength.

Table 2 illustrates the minimum and maximum as well as the average moduli of elasticity produced by the three cures. Figure 5 shows the progressive increase in the modulus, as the curing time becomes greater. It will be noted here that there is nowhere nearly so great an increase in the modulus from Cure 2 to 3 as there is from 1 to 2.

3. *Tensile Strength.*—Tensile strength tests were made on specimens of the three cures, following as nearly as possible the procedure recommended by the U. S. Bureau of Standards[8] and the American Society for Testing Materials.[9]

Vulcanite has rather a high tensile strength and a relatively slight ultimate elongation. In this manner, its tensile properties resemble those of a metal.

The machine used in this test was an Olsen universal testing machine. Special grips and clamps were used for holding the specimens. (Fig. 6.) The breaking load, or measured tensile strength, is indicated by the load on the beam. The loading time was at the rate of 30 pounds per minute.

The ultimate tensile strength in pounds per square inch was calculated from the formula:

$$X=\frac{S}{A}$$

where X=ultimate tensile strength, pounds per square inch; S=stress applied (breaking load), pounds; A=area of test piece=bd; where b=width, inches; d=thickness, inches.

Test strips were dumb-bell-shaped, having been vulcanized in molds of the appropriate shape and size, as shown in Figure 1. The distance between the jaws of the grips was 3 cm.

In specimens from Cure 1, there was a marked yield point just before they broke. They stretched decidedly, and then broke.

Test strips from Cure 2 showed a less marked yield point, and their measured and ultimate tensile strength were both found to be about 30 per cent greater than in Cure 1.

Cure 3 was but very little different from Cure 2. Its yield point was slight, and its average measured tensile strength was actually 2 pounds less than that for Cure 2, although its ultimate or calculated tensile strength was found to be 2 per cent greater than that with Cure 2.

TABLE 3.—TENSILE STRENGTH OF VULCANITE*

Cure	Average Breaking Load Pounds	Ultimate Tensile Strength Range	Pounds per Square Inch Average
1	161.7	4,022 — 4,876	4,474
2	237.3	6,016 — 6,721	6,374
3	235.0	6,274 — 6,894	6,489

*Using an Olsen Universal Testing Machine; loading rate, 30 pounds per minute.

TABLE 4.—FLEXURAL STRENGTH OF VULCANITE (TRANSVERSE STRENGTH)*

Cure	Average Breaking Load Pounds	Average Bend Inches	Maximum Fiber Stress Pounds per Square Inch Range	Average
1	14.00	1.000	10,650 — 11,150	11,080
2	14.97	0.297	11,430 — 12,120	11,883
3	15.80	0.267	12,510 — 13,060	12,720

*Using a special dynamometer spring machine; loading rate, 8-10 pounds per minute.

8. Footnote 4, p. 75.

9. American Society for Testing Materials, Tentative Standards, 1934, p. 893.

Table 3 shows the average breaking loads in pounds for the three cures, as well as the range and the average ultimate tensile strength, in pounds per square inch.

Figure 7 shows how the ultimate tensile strength increased as the curing time increased.

The change is slight from 2 to 3 as compared with 1 to 2.

4. *Flexural Strength (Formerly Called Transverse Strength).*—The machine used was developed at the University of Michigan Dental School and was originally used to measure the flow of dental amalgams. It was designed and described by Ward.[10]

The apparatus, as shown in Figure 8, consists of a horizontal dynamometer spring which has been ground to a sensitivity of 15-20 gm. Recording dials have been attached to the machine as shown. One, attached to the spring, records the displacement of the spring, or the stress applied. The other dial records the distance through which the machine travels in testing the specimen. The difference between the reading of the "spring" dial and the "distance" dial is the amount the test strip has bent. The slight spring tension in the "distance" dial increases the sensitivity of the machine to less than 5 gm. The specimen rests horizontally and on edge against supports which are 1½ inches apart. The force is brought to bear flatwise on the face of the strip, at a point in the middle of the strip. Thus, a transverse load is applied.

This machine is unique in that it measures the amount of bend of the test specimen as well as the load applied up

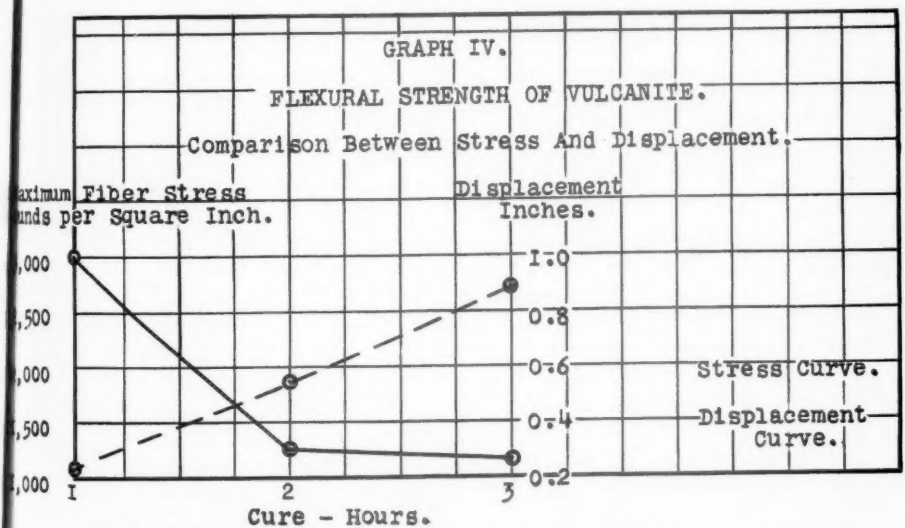

Fig. 9.—Graph showing relation between flexural strength and displacement of various curves. The dotted line indicates the stress curve; the solid line, the displacement curve.

10. Ward, M. L.: Further Variations in Effect of Manipulation on Dimensional Changes and Flow of Amalgams, J.A.D.A., 22:1164 (July) 1935.

to the breaking point. In this manner, a clearer knowledge is gained of its strength.

This test follows as closely as possible the procedure recommended by the American Society for Testing Materials.[11]

The maximum fiber stress or force applied in pounds per square inch is calculated from the formula given in the A. S. T. M. Tentative Standards:

$$S = \frac{3Pl}{2bd^2}$$

where S=maximum fiber stress; P=breaking load, pounds; l=distance between supports, inches; d=thickness of specimen, inches; b=width of specimen, inches.

Specimens from Cure 1 did not break. They bent the full limit of the machine, more than an inch, a load of 14 pounds being required to accomplish this. They cracked on the side away from the applied force, but did not break completely.

Those of Cure 2 broke after bending an average amount of 0.297 inch and the average breaking load was 14.97 pounds.

With Cure 3, the average breaking bend was 0.267 inch and the average breaking load was 15.8 pounds.

Table 4 records the average bend, or displacement at the breaking point; as well as the average breaking load applied. The maximum fiber has been calculated, and is also recorded.

Figure 9 presents two curves, one of which traces the maximum fiber stress increase from Cure 1 to Cure 3; and the other shows the decrease in the amount of bend or displacement from Cure 1 to Cure 3.

It is interesting to note the large displacement and the relatively small stress of Cure 1, as compared to the much

Table 5.—Impact Strength of Vulcanite*

Cure	Average Breaking Load Inch-Pounds	Ultimate Stress Range	Inch-Pounds per Inch Average
1	2.50	50.45 — 89.32	72.72
2	3.36	75.50 — 124.50	95.67
3	3.66	85.66 — 115.50	98.58

*Using a special light-weight impact machine (Charpy type); 15 inch-pound capacity.

Table 6.—Flexure Fatigue of Vulcanite*

Cure	Number of Flexures	Stress Applied Range	Pounds per Square Inch Average
1	650,000†	1,963 — 2,134	2,057
2	4,000,000‡	2,792 — 2,852	2,817
3	15,000,000#	3,197 — 3,248	3,223

*Using a special fatigue machine producing direct stress; displacement, 0.078 inch.
†With Cure 1, two specimens broke and the third went for 15,000,000 flexures without breaking.
‡With Cure 2, one specimen broke and the other two ran for 15,000,000 flexures without breaking.
#With Cure 3, one specimen broke and the other two remained intact after 15,000,000 flexures.

11. Footnote 9, p. 895.

smaller displacements and the far greater loads of Cures 2 and 3.

5. *Impact Strength.*—This test followed as closely as possible, the procedure outlined by the American Society for Testing Materials.[12] A special lightweight impact machine of the Charpy type designed and built in the University of Michigan Engineering Shops was used. (Fig. 10.)

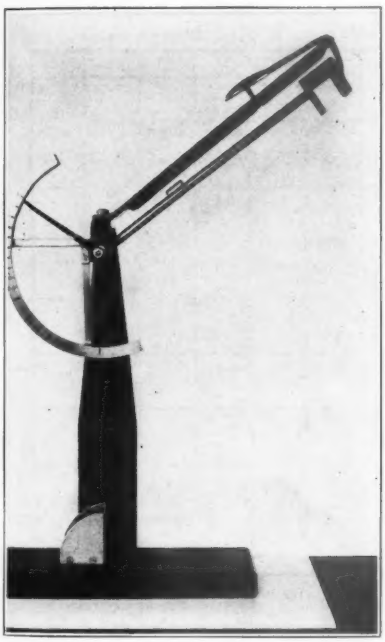

Fig. 10.—Charpey type machine for measuring impact strength, specially designed for testing thin specimens.

This machine had a 15 inch-pound capacity and was designed for use with thin strips. It is much lighter in weight than the standard 40 cm.-kg. machine, which is intended to accommodate notched specimens one-half inch thick.

12. Footnote 9, p. 821.

In this test, the specimen is held horizontally as a simple beam in supports one and one-half inches apart. It is broken by a blow delivered flatwise midway between the supports.

The American Society for Testing Materials states that the specimen may be either plain or notched, this depending on the characteristics of the material tested. Notching was unnecessary with these thin vulcanite specimens, as breakage occurred in every case.

The machine, which is of the pendulum type and of rigid construction, follows the requirements of the A. S. T. M. The American Society for Testing Materials also states that the value of energy absorbed in each individual test should be expressed in foot-pounds per inch of notch. This is determined by dividing the energy in foot-pounds per inch of notch in the individual test by the actual dimensions in inches.

With this smaller machine, which is calibrated in inch-pounds, the results would be recorded as inch-pounds per inch, and are determined by dividing the energy in inch-pounds required to break each strip by the cross-sectional area of the strip.

It was found that it took about 25 per cent less energy to break strips from Cure 1 than those from Cure 2, in spite of the fact that these specimens were the most flexible of the lot. It required only about 3 per cent more energy to break specimens from Cure 3 than to break those of Cure 2.

Table 5 records the average force in inch-pounds; and also the range and average force in inch-pounds per inch required to break the test specimens. Figure 11 illustrates the progressive increase in impact strength from Cure 1 to Cure 3.

6. *Flexure Fatigue.*—A denture in the mouth is subjected to constant bending

stresses, and it was felt that some information on the length of time which the denture material would withstand this continual bending would have a decided value. Accordingly, tests were made on the flexural fatigue of the vulcanite specimens.

In making these determinations, there were very few data that could be used. Practically all such information is concerned with metals. The machine used was one that was developed at the University of Michigan Dental School, and built in the engineering shops of the University. It is described by Peyton.[13] (Fig. 12.) The machine is so constructed that six specimens may be tested at once. The pieces are clamped in a vertical position with the upper ends fixed rigidly, while the lower end is fastened to a movable clamp, which is in turn attached to an eccentric cam controlling the amount of displacement. The displacement is adjustable, and may be controlled to 0.001 inch. An attached instrument records the number of deflections given to the specimens.

The machine was so constructed that when a test strip broke, it stopped automatically. It was driven by an electric motor at the rate of 300 flexures per minute.

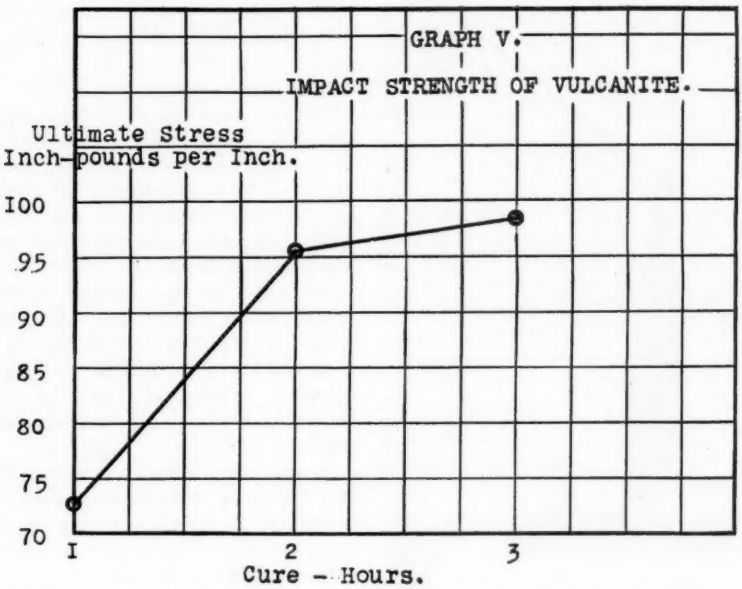

Fig. 11.—Graph showing relation between various curves as regards impact strength.

Barber[2] used alternating stresses in his work on flexure fatigue. In this present investigation, it was felt that a denture in the mouth and under the stress of chewing bent in only one direction, and then back to its original position. This would be a direct, and not an al-

13. Peyton, F. A.: Flexure Fatigue Studies of Cast Dental Gold Inlays, J.A.D.A., 21:394 (March) 1934.

ternating, stress. With alternating stress, greater stress is applied to the specimen and breakage is much more likely to occur; but this is not a true picture of what happens in the mouth. With this in mind, the machine was set to test the specimens by applying direct stress.

The amount of displacement was more or less arbitrary, as there is no standard for this test on vulcanite. The concensus of opinion of a number of dentists was taken. They agreed that 2 mm. was probably much more than the average denture would bend when in use, and that it would be better, within certain limits, to bend the specimens too far than not far enough. Accordingly, the machine was set to deliver a displacement of 0.078 inch, which is a very slight amount less than 2 mm. It will be recalled that in the determination of the modulus of elasticity, 2 mm. was found to be the elastic limit of these specimens, and that a bend much over that amount produced permanent distortion. Fatigue tests should be kept within the elastic limit of the material in order to have any practical value, and the displacement of 0.078 inch fulfilled this requirement.

Three specimens of each cure were tested. Two strips from Cure 1 broke very soon; one after 390,000 flexures, and the other after 1,000,000. The third did not break after 15,000,000 bends. Of those from Cure 2, one broke after 4,000,000, and the other two did not break after 15,000,000. From Cure 3, one specimen broke at 15,000,000 flexures, and the other two were still intact.

It was considered impractical to run the specimens for any longer than 15,000,000 flexures, for this reason: It has been estimated that one closes his mouth approximately 10,000 times per week, or about 500,000 times a year. Thus, 15,000,000 flexures would be, roughly, the equivalent of thirty years' wear.

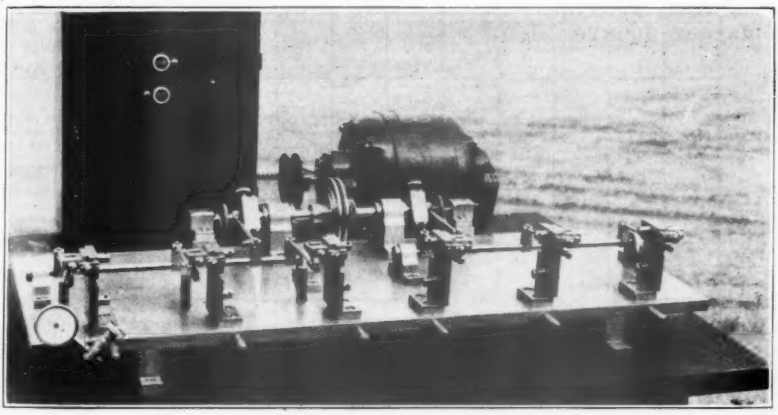

Fig. 12.—Machine for measuring flexure fatigue.

The stress applied to the specimens by the fatigue machine was calculated from the formula:

$$S=\frac{1.5\ b\ d\ E}{l^2}$$

where S=stress in pounds per square inch; 1.5=a constant; b=thickness in

inches; d=deflection in inches; E=modulus of elasticity in pounds per square inch; l=length in inches.

The stress on specimens from Cure 1 was found to average 2,057 pounds per square inch. That on strips from Cure 2 was 27 per cent greater, and with Cure 3, 38 per cent higher.

Table 6 shows the range and the average stress applied to specimens of the three cures, and records the number of deflections as well.

Figure 13 illustrates the increase in stress from Cure 1 to Cure 3.

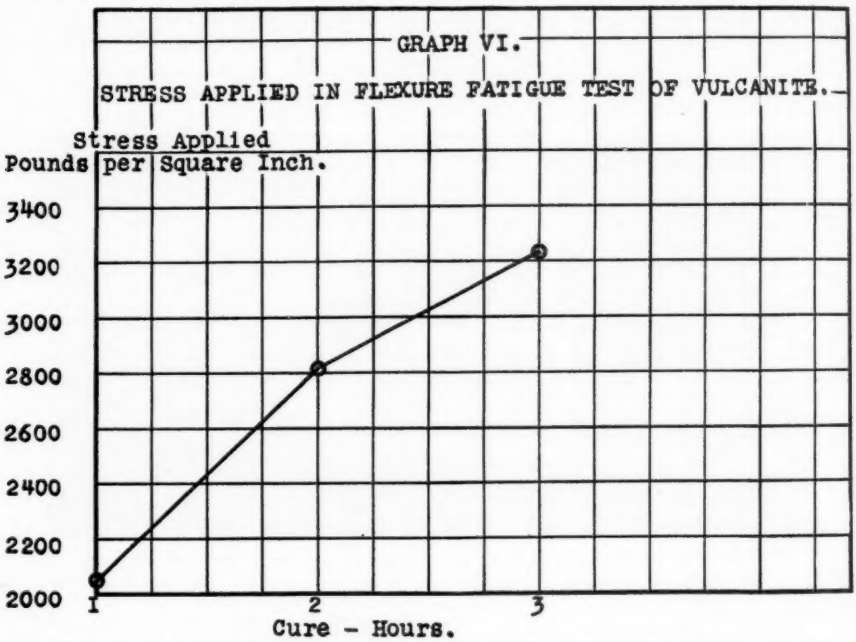

Fig. 13.—Graph showing relation between various curves as regards applied stress in flexure fatigue.

CONCLUSIONS

1. The three hour cure produced harder vulcanite than either of the shorter cures. Its Brinell hardness number was 37 per cent greater than that of Cure 1; and 9 per cent higher than that of Cure 2. There is comparatively little difference in the hardness of Cures 2 and 3.

2. Cure 3 produced specimens that were stiffer than those of the two other cures. Its modulus of elasticity was 36 per cent greater than that of Cure 1 and 13 per cent higher than that of Cure 2. Again, there is but slight difference between 2 and 3.

3. Cure 3 had an ultimate tensile strength that was 32 per cent greater than that of Cure 1, but only 2 per cent more than that of Cure 2. Even less difference is noted between 2 and 3 than with the preceding two tests.

4. The flexural strength of Cure 3

was 13 per cent higher than that of Cure 1, but only 7 per cent more than that of Cure 2. There is still little difference between 2 and 3, but the increase in strength from 1 to 3 is quite uniform.

The amount of displacement showed a greater difference between the cures. Specimens from Cure 1 bent over an inch without breaking; while with Cure 3, with 13 per cent more stress applied, they bent only 0.267 inch and then broke. In comparison to specimens from Cure 2, those from Cure 3 bent 7 per cent less, although they received 7 per cent more stress.

5. The impact strength of Cure 3 was found to be 26 per cent greater than that of Cure 1, and but 2 per cent more than that of Cure 2. The slight difference between 2 and 3 is still noted.

It is of interest here to note that specimens from Cure 1, which are undercured and soft, broke more readily than those from either of the other cures; and specimens from Cure 3, which would be expected to be most brittle because of their prolonged cure, had the greatest impact strength of the group.

6. With flexure fatigue, Cure 3 was found to have an applied stress 63 per cent more than that of Cure 1 and only 12 per cent higher than that of Cure 2.

It is questionable whether this test is of any particular value in these strength determinations on vulcanite. In Cure 1, two of the three specimens broke in less than 1,000,000 flexures; while the third went 15,000,000 times without breaking.

With Cure 2, although one strip broke after 4,000,000 flexures, the other two went 15,000,000 without breaking.

Only one specimen from Cure 3 broke, and that was after 15,000,000 flexures. The remaining two strips were, as far as could be determined, intact.

From such indefinite data, it is evident that no definite conclusions can be drawn in regard to the flexure fatigue of vulcanite. It is apparent that this property does not seem to play so important a part in the failure of vulcanite dentures as has been supposed. On the other hand, there is room for argument here. If, as many believe, the denture continues to be cured and aged while in the mouth, it is possible that after it has been in use for a certain length of time, flexure fatigue may become a great factor in the breakage of the denture. It is very difficult to prove this point one way or the other.

SUMMARY

While the data in this report are based upon a limited number of tests intended primarily to develop tests for denture materials, certain observations have been made which seem to indicate the following:

1. Vulcanite may be tested in thin sheets approximating the thickness of dentures.

2. A sufficiently large number of tests seem to be available to cover every form of stress created in this material when it is used in dentures.

3. It appears that the one hour cure of vulcanite does not develop the most desirable properties.

4. There does not appear to be so much difference in strength between the two and the three hour cures as was anticipated at the beginning of the study.

It is intended in the near future to utilize the experiences, the equipment and the data obtained in this study to make comparisons with other denture materials, and to determine the properties of vulcanite more accurately than has been possible in this preliminary survey.

514 Chalmers Avenue.

TRIPPING ACTION OF BAR CLASPS*

By EUGENE R. STONE, D.D.S., Washington, D. C.

IT is hardly necessary among dentists to emphasize the thought that, because of the many variables encountered, partial denture design and construction cannot be reduced to an exact science or rigid formula wherein problems can be solved categorically for all cases. Rather must it be practiced as an art which borrows from science to apply principles to each particular case, wherein compromising and conflicting factors will tend to limit their full use. It will continue to tax our capacities to analyze the causes that militate against success and we will even continue to be oblivious of factors that operate advantageously in our successes. We all realize that he who undertakes a partial denture to meet all the specifications that could be desired has a real task even if there be agreement as to specifications.

The wonders worked by the orthodontist naturally evoke admiration, but if it is spectacular to move teeth, what should be said of him who must practice orthodontia in reverse by not moving them? It is easier to move than to be still, especially when dealing with changing forces in constant operation. This thought is put forth not to excuse anything short of our best efforts, but rather to emphasize at the outset the difficulties and exacting demands entailed and the urgent need of greater efficiency. There is need to be receptive, analytic and alert in order to consider and recognize the merit of new work and to be roused from the defeatist attitude that nothing much better than present methods is possible for these cases. Progress entails experiment, and while all experiments are not successful, and while it is difficult to be enterprising without falling into error, it is also deadly to be too complacent. I have chosen to confine myself to a principle that seems to operate to distinct advantage in retention and stabilization, to which I can find no previous reference in the literature. This theme deals with a simple and elemental principle of physics, which, for the lack of any specific engineering term, has been labeled "tripping action," not in the sense of a release or trigger action, but in the sense of stumbling action, which operates in many of the bar clasps, but not in the orthodox horizontal or diagonal circumferential clasps. The gist of my effort is to show that by the too wide use of the horizontal circumferential clasp, as far as retention and stabilization are concerned, we have been unwittingly increasing our already overwhelming handicaps and have been literally working upside down. While there will no doubt continue to be a place for the horizontal clasp, the issue is raised, in view of what follows, as to whether it should not be given second choice to the bar clasp, and then used only in cases wherein malposed or tilted teeth and consequent deep undercuts make it impracticable to use the bar clasp.

This question is raised in the face of the fact that many horizontal type clasp cases

*Read at the New York Dental Centennial, New York City, Dec. 5, 1934.

are serving so efficiently that apparently they leave nothing to be desired. We are not disposed to dispute such testimony of the patient. Any attempt to compare the experiences of those partial to one type with the experiences of those partial to the other would without doubt serve only to confuse. And it would seem wise first either to prove or to refute the proposition from a theoretical standpoint and to attempt to explain these horizontal type successes afterward. There is no presumption to subvert or question the value of the time-proved horizontal clasp. This is presented rather as a hypothetical question for the purposes of analysis and to stimulate thought and reaction on the part of others in order to supply the other side of the picture or other factors that may have been overlooked.

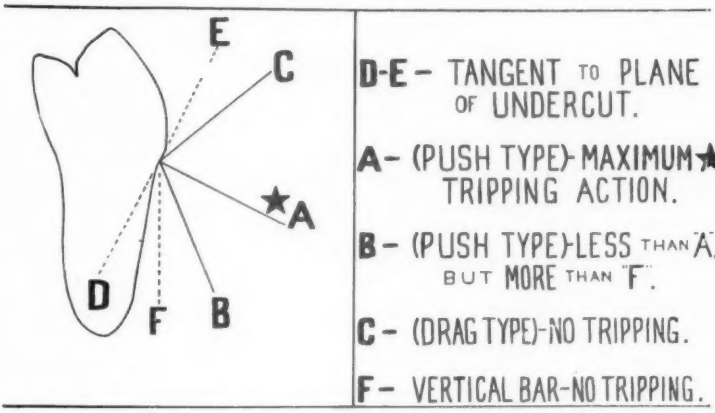

Fig. 1.—Effect of angle of incidence of clasp bar on tripping action.

(SCHEMATIC)
A
C
D
PUSH TYPE
HORIZONTAL CLASPS AND VERTICAL BAR CLASPS OCCUPY NEUTRAL ZONE WHICH IS DIDING LINE DETERMINING WHERE TRIPPING ACTION VANISHES. (FIG. 1, "F")
THICKER BARS WITH LARGER BEARING SURFACES.
B
E
F
DRAG TYPE
RETENTION IN "A" IS GREATER THAN "B" BECAUSE INCLINED PLANE AT "C" IS MORE NEARLY AT RIGHT ANGLE TO LONG AXIS OF "C-D", WHEREAS SAME INCLINED PLANE AT "F" IS MORE NEARLY PARALLEL TO THE LONG AXIS OF "E-F" THEREFORE "E-F" WILL BEND OUTWARD EASIER THAN "C-D."

Fig. 2.—Comparative analysis push and drag type clasps.

OBSERVATION OF DIFFERENCE IN ACTION OF TWO TYPES OF CLASPS

It is believed that those who have had experience with both types of clasps have observed that the horizontal or diagonal type is inserted with more difficulty than it can be removed; while the reverse is true of the Roach bar type case, which goes to place more easily than it can be removed, and, on insertion, after passing the greatest tooth convexity, tends to snap into place and stay down on its seat, resisting better any tendency to rocking movements, even without severe spring tension. And while it is true that some of these successful horizontal type clasps do the same, it is believed that it is because they have the benefit of positive spring tension and definite undercuts.

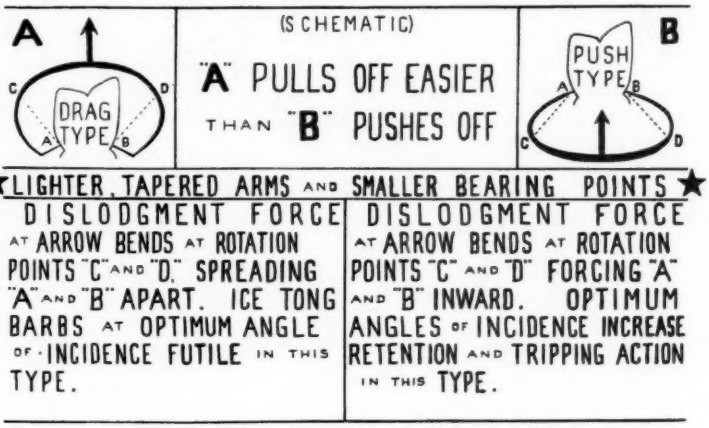
A
C
D
DRAG TYPE
A
B
(SCHEMATIC)
"A" PULLS OFF EASIER THAN "B" PUSHES OFF
B
PUSH TYPE
A
B
C
D
★LIGHTER, TAPERED ARMS AND SMALLER BEARING POINTS★
DISLODGMENT FORCE AT ARROW BENDS AT ROTATION POINTS "C" AND "D," SPREADING "A" AND "B" APART. ICE TONG BARBS AT OPTIMUM ANGLE OF INCIDENCE FUTILE IN THIS TYPE.
DISLODGMENT FORCE AT ARROW BENDS AT ROTATION POINTS "C" AND "D" FORCING "A" AND "B" INWARD. OPTIMUM ANGLES OF INCIDENCE INCREASE RETENTION AND TRIPPING ACTION IN THIS TYPE.

Fig. 3.—Comparison of drag and push type clasps.

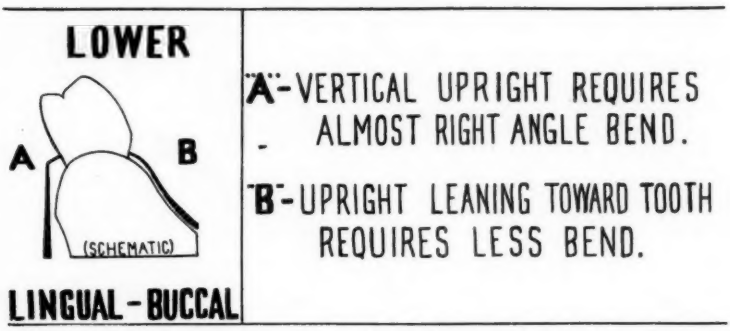

Fig. 4.—Variation of bend necessary to provide optimum angle of incidence, depending on inclination of upright.

Surely there can be no doubt as to the desirability of these features of the bar clasp. They are desirable because they fulfil more positively and abundantly the very functions of clasps. They are de-

sirable not so much because we always need more resistance to dislodgment force than the horizontal type affords, although this is true in many instances of short teeth lacking undercuts, but because of creased resistance to dislodgment force of the push type bar clasp tends to make it slip toward its seat with a snapping effect, because there is an increased spreading tension between the occlus-

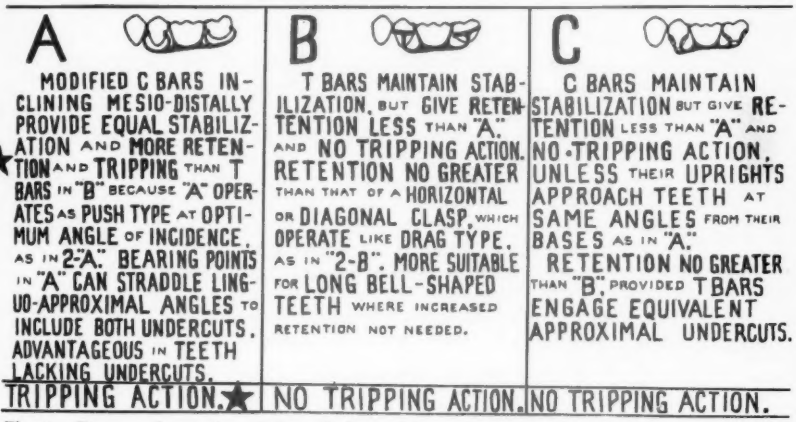
A
MODIFIED C BARS INCLINING MESIO-DISTALLY PROVIDE EQUAL STABILIZATION AND MORE RETENTION AND TRIPPING THAN T BARS IN "B" BECAUSE "A" OPERATES AS PUSH TYPE AT OPTIMUM ANGLE OF INCIDENCE, AS IN 2-"A." BEARING POINTS IN "A" CAN STRADDLE LINGUO-APPROXIMAL ANGLES TO INCLUDE BOTH UNDERCUTS. ADVANTAGEOUS IN TEETH LACKING UNDERCUTS.
TRIPPING ACTION.★
B
T BARS MAINTAIN STABILIZATION, BUT GIVE RETENTION LESS THAN "A." AND NO TRIPPING ACTION. RETENTION NO GREATER THAN THAT OF A HORIZONTAL OR DIAGONAL CLASP, WHICH OPERATE LIKE DRAG TYPE, AS IN "2-B". MORE SUITABLE FOR LONG BELL-SHAPED TEETH WHERE INCREASED RETENTION NOT NEEDED.
NO TRIPPING ACTION.
C
C BARS MAINTAIN STABILIZATION BUT GIVE RETENTION LESS THAN "A" AND NO TRIPPING ACTION, UNLESS THEIR UPRIGHTS APPROACH TEETH AT SAME ANGLES FROM THEIR BASES AS IN "A." RETENTION NO GREATER THAN "B", PROVIDED T BARS ENGAGE EQUIVALENT APPROXIMAL UNDERCUTS.
NO TRIPPING ACTION.

Fig. 5.—Comparative action of three designs of lower lingual unilateral case where uprights are always vertical.

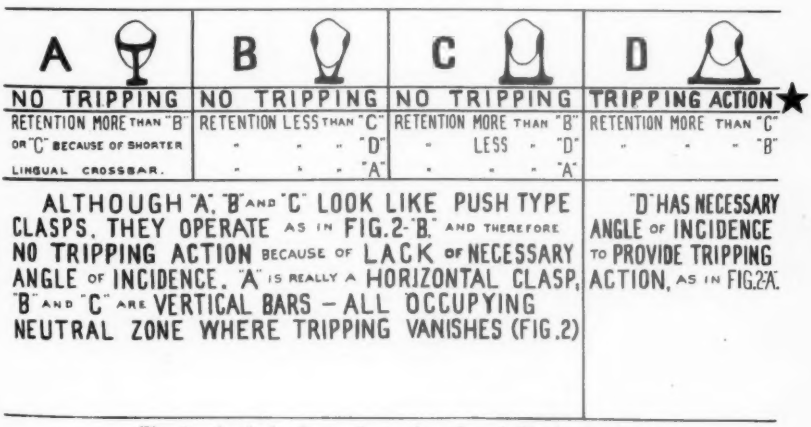
A
NO TRIPPING
RETENTION MORE THAN "B" OR "C" BECAUSE OF SHORTER LINGUAL CROSSBAR.
B
NO TRIPPING
RETENTION LESS THAN "C" " " "D" " " "A"
C
NO TRIPPING
RETENTION MORE THAN "B" " LESS " "D" " " "A"
D
TRIPPING ACTION ★
RETENTION MORE THAN "C" " " "B"
ALTHOUGH "A", "B" AND "C" LOOK LIKE PUSH TYPE CLASPS, THEY OPERATE AS IN FIG. 2-"B." AND THEREFORE NO TRIPPING ACTION BECAUSE OF LACK OF NECESSARY ANGLE OF INCIDENCE. "A" IS REALLY A HORIZONTAL CLASP, "B" AND "C" ARE VERTICAL BARS – ALL OCCUPYING NEUTRAL ZONE WHERE TRIPPING VANISHES (FIG. 2)
"D" HAS NECESSARY ANGLE OF INCIDENCE TO PROVIDE TRIPPING ACTION, AS IN FIG. 2-"A."

Fig. 6.—Analysis of retentive action of mesiodistal grip clasps.

the reversed direction of any tendency to slip or spring from undercuts, and because of more effective stabilization. If there be any such tendency, the inal rests and the bearing points of the clasps, due to increased resistance of the push type over the drag type, as it will be attempted to prove. And this spread-

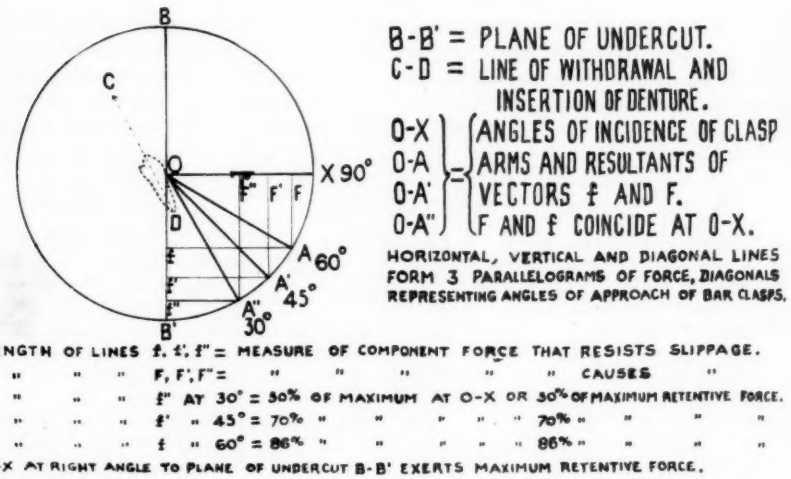
B
C
O
X 90°
F" F' F
D
A 60°
A' 45°
A" 30°
B'
B-B' = PLANE OF UNDERCUT.
C-D = LINE OF WITHDRAWAL AND INSERTION OF DENTURE.
O-X
O-A
O-A'
O-A"
ANGLES OF INCIDENCE OF CLASP ARMS AND RESULTANTS OF VECTORS f AND F.
F AND f COINCIDE AT O-X.
HORIZONTAL, VERTICAL AND DIAGONAL LINES FORM 3 PARALLELOGRAMS OF FORCE, DIAGONALS REPRESENTING ANGLES OF APPROACH OF BAR CLASPS.
LENGTH OF LINES f, f', f" = MEASURE OF COMPONENT FORCE THAT RESISTS SLIPPAGE.
" " " F, F', F" = " " " " " CAUSES "
" " " f" AT 30° = 50% OF MAXIMUM AT O-X OR 50% OF MAXIMUM RETENTIVE FORCE.
" " " f' " 45° = 70% " " " " " 70% " " " "
" " " f " 60° = 86% " " " " " 86% " " " "
O-X AT RIGHT ANGLE TO PLANE OF UNDERCUT B-B' EXERTS MAXIMUM RETENTIVE FORCE.

Fig. 7.—Measure of values of two component forces at varying angles of incidence of clasp arms to plane of tooth undercut.

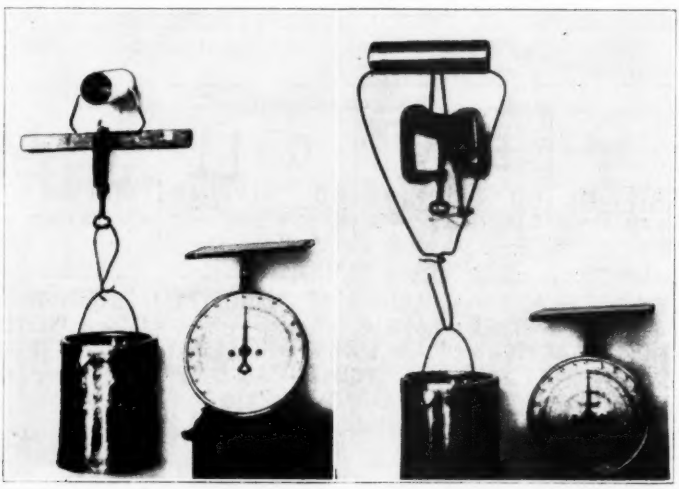

Fig. 8.—Left: Pull test: Cylinder fixed to bench, weight hung on clasp. Left: Push test: Same clasp fixed to bench, weight hung on cylinder.

ing tension between the occlusal rest and bearing point of the bar clasp, on account of this differential in resistance of the push over the pull, has the effect of reversing the direction of slippage tendency. On the other hand, in the horizontal type, any tendency to slippage must always be in the direction of dis-

lodgment, because it slips off more easily than it goes on. Bringing this difference into sharp focus reveals the most outstanding feature of the bar clasp and the best reason in the world for using it.

FACTORS IN RETENTION

To avoid confusion in what follows, a distinction should be made between the factors in retention. The word "retention" connotes primarily the direct gripping or clutch action of a clasp, which is influenced by the tension, length, mass and cross-sectional shape of the clasp arm, and torsion, if the curvatures are in more than one plane, and by tripping action yet to be explained. Another factor in retention, which arises from resisting the rocking tendency, where the occlusal rests act as trunnions, is the so-called stabilizing action, which is influenced by the width, thickness, cross-sectional shape and tension of the clasp arms, the distance from the occlusal rest to the lowest point of that same clasp-bearing area toward the gingiva, the distance from each occlusal rest to the farthest point of the seat or bearing surface of the entire denture and also the tripping action. Both retention and stabilization are influenced by a third condition, tripping action, which depends on the angle at which a bar clasp, and a bar clasp only, approaches the tangential plane of the tooth undercut. (Fig. 1.) All three factors can be affected by torsion.

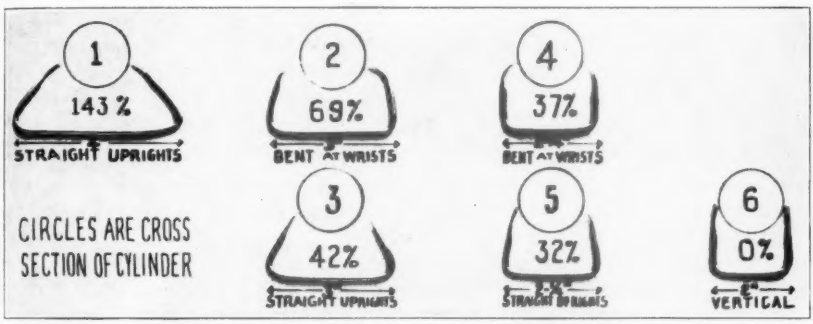
1
143 %
STRAIGHT UPRIGHTS
2
69%
BENT AT WRISTS
4
37%
BENT AT WRISTS
3
42%
STRAIGHT UPRIGHTS
5
32%
6
0%
VERTICAL
CIRCLES ARE CROSS SECTION OF CYLINDER
INCREASE OF RESISTANCE OF TOOTH BULGE IN PUSH OVER DRAG TESTS.
BY WEIGHTS HUNG FIRST ON CYLINDER, THEN ON CLASPS, SHOWING % INCREASE OF PUSH OVER DRAG.
THE PERCENTAGE OF DIFFERENCE DECREASES PROGRESSIVELY ① TO ⑥ AS UPRIGHTS APPROACH VERTICAL BY NARROWING CLASP BASES.
① MAXIMUM – UPRIGHTS STRAIGHT AT RIGHT ANGLE TO TANGENT PLANE OF UNDERCUT.
② EXCEEDS ③ AND ④ EXCEEDS ⑤ BECAUSE OF WRIST BENDS, AND THIS WRIST BEND EFFECT DECREASES WITH NARROWER BASE.
⑥ TRIPPING ACTION CEASES IN BAR CLASP WITH VERTICAL UPRIGHTS.
② TO ⑤ COULD APPROACH % INCREASE IN ① BY THICKER ELBOWS IN LOWER PORTIONS OF UPRIGHTS TO RESIST OUTWARD BENDING MOMENT.

Fig. 9.—Increase of resistance of tooth bulge in push over drag tests.

DESCRIPTION OF TRIPPING ACTION

Let it be emphasized that all circumferential clasps, including the horizontal or diagonal, the Jackson crib and the Gillette clasp, as they proceed from the occlusal rests down and around the sides of the tooth, grasp the tooth in such a manner that the long axes of their arms are in a plane or planes parallel to the sides of the tooth; whereas, in contradistinction to these, the long axis of the bar clasp, which usually leans somewhat toward the tooth, is not parallel to the sides of the tooth, but leads up to it at more or less of an angle. It will be realized that the horizontal clasp is taking the load of bending force at right angles to its long axis, the direction which puts the greatest strain on a cantilever and can be compared to the human arm supporting a weight when extended horizontally; while the bar clasp, which leans toward the plane of the side of the tooth at somewhat of an angle, takes the load of bending force, not entirely at right angles to its long axis, but partly in line with its long axis, and therefore will resist the outward bending force better, just as the human arm would support that same weight more easily when extended upward overhead vertically.

This has been an abstruse problem, rather difficult to define, and, as I look backward, it would seem that it is the difficulty or failure to keep a clear mental picture of this important difference in the relation of the plane of the undercut to the long axis of the clasp arm that accounts for most of the confusion, doubt and uncertainty experienced. Emphasis is placed on this now because all that follows depends on it. The simplest tangible comparison is the act of pushing a stick ahead along the sidewalk, where a tripping or stumbling resistance is likely to be encountered, and of dragging the stick behind at the same angle, where the same effect is lacking. The plane of the tooth undercut more nearly at right angles to the long axis of the clasp arm will offer greater resistance to dislodgment for the same reason that it is easier to push a stick along the ground

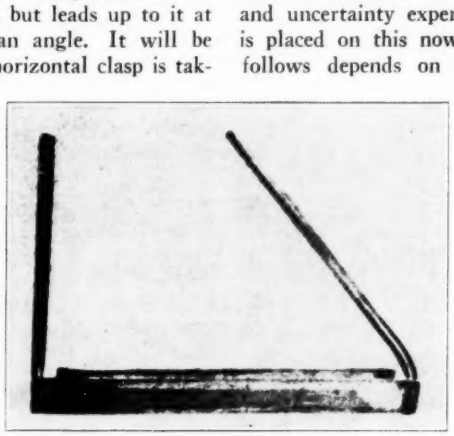

Fig. 10.—Test simulating horizontal and bar clasp arms on opposite sides of same tooth. Push and pull tests show a differential in favor of the push, indicating tripping action, but less than that of two bar arms at the same angle. In practice, where a horizontal clasp is used on one side of a tooth and a bar clasp on the other, the full efficiency of two bars can be attained by stiffening the horizontal arm to compensate.

the more nearly parallel to the ground the stick is.

PUSH AND PULL TYPES OF CLASPS

A simple classification would characterize the bar clasp as a push type and the circumferential clasp as the pull or drag type. All drag type clasps, it will be seen, whether they traverse the teeth horizontally, diagonally or directly vertically from the occlusal aspect, all other relevant factors being equal, will retain a case with equal efficiency, because the long axes of their arms are all parallel with the sides of the tooth. Therefore, it will be seen that it will be permissible for convenience in illustrating diagrams and demonstration tests to represent the

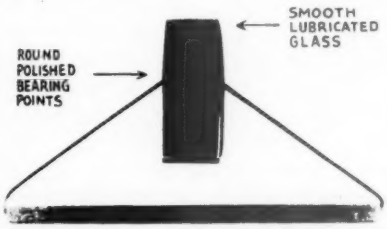

Fig. 11.—Tripping action operating even on parallel smooth lubricated surfaces. The base of the clasp rests on the table in the push test with just sufficient spring tension to sustain the glass weight. When inverted on the pull test, the glass weight slips out. The delicate difference of this severe test is of questionable significance on the direct line of withdrawal, but might operate favorably in the curved line of withdrawal of rocking movements where a tooth surface lacking undercut acquires a positional undercut.

action of the horizontal and diagonal clasps by arms coming directly from the occlusal. (Fig. 2*B*.)

SIGNIFICANCE OF DIFFERENCE IN POINT OF ATTACHMENT OF CLASP ARMS TO BODY OF DENTURE IN TWO TYPES OF CLASPS (FIG. 3)

Before proceeding to analyze the difference in action of these two types of clasps, it might be helpful to visualize the following comparison: In the case of the horizontal type, owing to the point of attachment of the clasp arm to the body of the denture above the tooth bulge, the mass of the body of the denture is already past the undercut, and hangs by a less effective dragging and glancing action, grasping at the last straw, so to speak, which makes necessary more positive spring tension and constant contact; whereas, in the bar clasp type, owing to the point of attachment of the clasp arm to the body of the denture below the tooth bulge, the passage of the body of the denture must follow release of clasps that tend to dig in (Fig. 3*B*), which produces a tripping or somersaulting tendency, a sort of circumferential action like the force that lifts the pole vaulter high in the air, and therefore gives a quality that retains a case on its seat, even with less severe spring tension.

TECHNICAL DESCRIPTION OF TRIPPING ACTION (FIG. 1)

The resistance to dislodgment, due to tripping action, is greatest when the arm of the bar clasp, under tension, approaches the infinitesimal plane of the tooth undercut at right angles in a straight line directly from its origin, and grows less as the clasp upright approaches the vertical, or is more nearly parallel to the plane of the undercut. (Fig. 1.) When the bar approaches the plane of the undercut at right angles, the resistance of the plane of the undercut is pitted at right angles to the long axis of the bar clasp arm, which prevents any outward bending of the bar, and therefore offers the greatest resistance. Progressively, any angle less than a right angle approach produces more and more bending force in the bar, which enables it to negotiate the bulge more easily, until it approaches the ver-

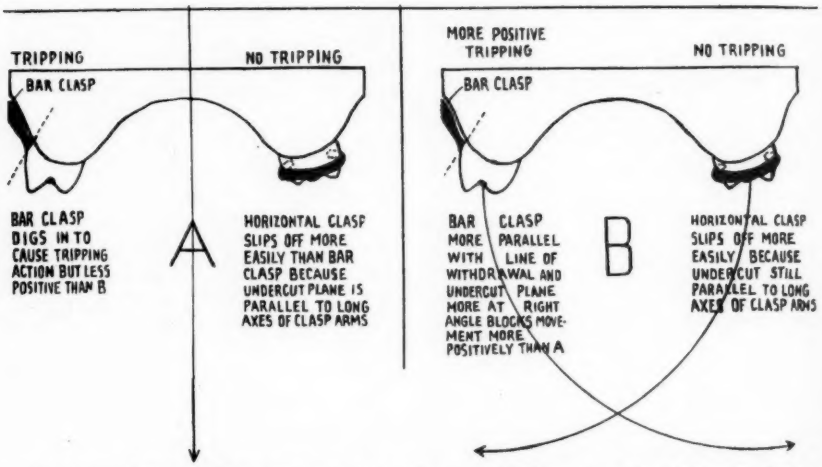
TRIPPING
NO TRIPPING
BAR CLASP
BAR CLASP DIGS IN TO CAUSE TRIPPING ACTION BUT LESS POSITIVE THAN B
A
HORIZONTAL CLASP SLIPS OFF MORE EASILY THAN BAR CLASP BECAUSE UNDERCUT PLANE IS PARALLEL TO LONG AXES OF CLASP ARMS
MORE POSITIVE TRIPPING
NO TRIPPING
BAR CLASP
BAR CLASP MORE PARALLEL WITH LINE OF WITHDRAWAL AND UNDERCUT PLANE MORE AT RIGHT ANGLE BLOCKS MOVEMENT MORE POSITIVELY THAN A
B
HORIZONTAL CLASP SLIPS OFF MORE EASILY BECAUSE UNDERCUT STILL PARALLEL TO LONG AXES OF CLASP ARMS

Fig. 12.—Effect of tripping action on stabilization. Left: Direct line of withdrawal. Right: Curved line of withdrawal.

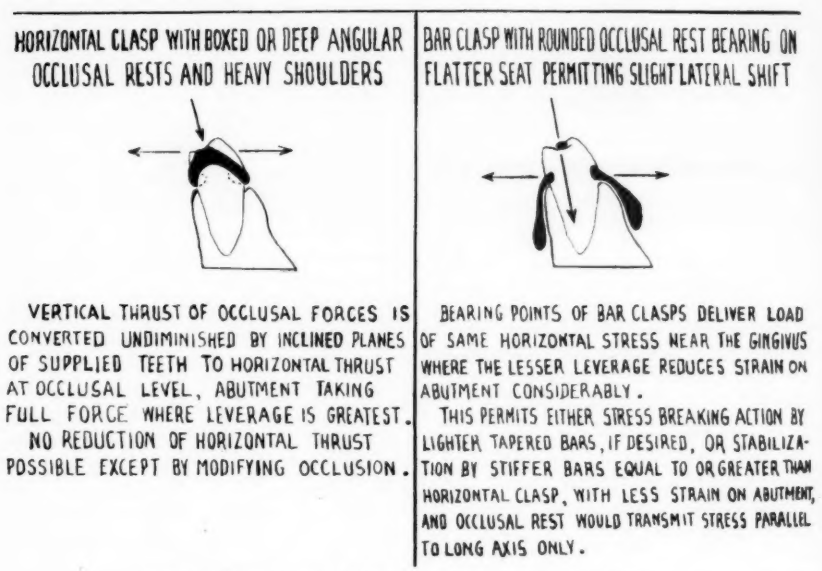
HORIZONTAL CLASP WITH BOXED OR DEEP ANGULAR OCCLUSAL RESTS AND HEAVY SHOULDERS
VERTICAL THRUST OF OCCLUSAL FORCES IS CONVERTED UNDIMINISHED BY INCLINED PLANES OF SUPPLIED TEETH TO HORIZONTAL THRUST AT OCCLUSAL LEVEL, ABUTMENT TAKING FULL FORCE WHERE LEVERAGE IS GREATEST.
NO REDUCTION OF HORIZONTAL THRUST POSSIBLE EXCEPT BY MODIFYING OCCLUSION.
BAR CLASP WITH ROUNDED OCCLUSAL REST BEARING ON FLATTER SEAT PERMITTING SLIGHT LATERAL SHIFT
BEARING POINTS OF BAR CLASPS DELIVER LOAD OF SAME HORIZONTAL STRESS NEAR THE GINGIVUS WHERE THE LESSER LEVERAGE REDUCES STRAIN ON ABUTMENT CONSIDERABLY.
THIS PERMITS EITHER STRESS BREAKING ACTION BY LIGHTER TAPERED BARS, IF DESIRED, OR STABILIZATION BY STIFFER BARS EQUAL TO OR GREATER THAN HORIZONTAL CLASP, WITH LESS STRAIN ON ABUTMENT, AND OCCLUSAL REST WOULD TRANSMIT STRESS PARALLEL TO LONG AXIS ONLY.

Fig. 13.—Comparative effect of horizontal stresses on abutments.

tical, where the tripping action virtually vanishes and the resistance to dislodgment is the same as that of the drag types. Likewise, any angle of approach more than a right angle produces a drag type effect and neutralizes any tripping action.

Thus, in practice, the angle should be something just short of a right angle, so that it will not exceed the right angle when tension brings the bar into function. For simplicity, it will be referred to as a right angle approach.

How to make bar clasps which must necessarily approach the undercut at less than a right angle equal in efficiency the bar at the ideal right angle approach is illustrated in Figure 4. The more nearly vertical the bar upright, the stiffer it should be to resist the outward bending force, if it be desired to maintain the tripping action efficiency of that which approaches in a straight line at right angles.

Fig. 14.—Difficult case of long divergent bell-shaped cuspids, providing adequate retention with minimum display of metal. The shape of the cuspids made it necessary to make over the case, a third attempt being required before there was effective retention with the least possible display of metal. Attempts to utilize mesial and distal undercuts made removal so difficult that it had to be abandoned. The incisal edges were grooved under the occlusal rests to provide a horizontal seat.

This can be accomplished by incorporating the necessary bend in the region of the gingival or wrist portion of the bar to direct the bearing point at right angles to the undercut plane and, at the same time, compensate for the increased outward bending force by stiffening the elbow and upright portion of the bar, progressively as the vertical is approached.

Exceptions occur where bar clasps fail to exert tripping action. (Fig. 6.) It will be obvious that tripping action does not operate in a mesiodistal grip clasp, because, while the bar does lean toward the tooth, it is not at right angles to the planes of the mesial and distal undercuts. The mesiodistal grip clasp with two separate upright bars can be made to exert tripping action only by having the upright bars lead up to the mesial and distal undercut planes from the mesial and distal aspects, either buccally or lingually, which would make them eye bars. C bars and T bars following the greatest contours of the buccal or lingual surfaces of the teeth are usually connected to the body of the denture with uprights that are more nearly vertical, and this, plus the fact that the offset bearing points at their ends introduce torsion, which tends to evade the undercut, much as if it were a coil spring instead of a bar, makes tripping action less in their case also. These can be made to exert tripping action only if they make contact with a gingival undercut where the upright first makes contact with the tooth at right angles, or some degree thereof, to its long axis. A

Fig. 15.—Case shown in Figure 14, side view. The space under the casting is intended to keep it midway of the baseplate.

C bar could exert tripping action by crossing the embrasure to the undercut plane on the adjoining tooth. (Fig. 5*C*.)

A mathematical demonstration of the theory and determination of absolute values for component forces of a bar clasp at any angle of approach to the undercut plane is given in Figure 7. Stated mathematically, the resistance of a bar clasp arm varies as the trigonometric sine of the angle of approach of the clasp arm to the plane of the undercut, and the sine is greatest when the arm is perpendicular or at right angles, i.e., the resistance is greatest when the resultant of all lines of force in dislodgment, which, in this case, is coincident with the long axis of the bar

Fig. 16.—Case shown in Figures 14-15, front view. The space under the casting is intended to keep it midway of the baseplate. The angle of approach of the bar as it curves in toward the gingival bearing point is to be noted.

upright, and which resultant force is composed of two component forces, one pushing toward the side of the tooth and tending to retain the case, and the other pushing toward the occlusal to release the case, is at right angles to the plane of the undercut, for it is then that they are most effectually stopped.

In Figure 7, the line *B-B′* is coincident to the plane of the undercut at the point *O*, and the line *C-D* is the axis of the tooth and is assumed to be the line of withdrawal of the case. At the point *O*, there is drawn the line *O-X* perpendicular to the line *B-B′*, and the lines *O-A″*, *O-A′* and *O-A*, respectively at 30, 45 and 60 degrees to the line *O-B*. If from the points *A″*, *A′* and *A*, we draw perpendicular lines *f″*, *f′* and *f*, and lines *F″*, *F′*, and *F* to the lines *O-B* and *O-X* respectively, the lines *O-A″*, *O-A′* and *O-A* represent the force exerted by the clasp bar or upright against the undercut, being really coincident with the uprights at these angles, the perpendicular and diagonal lines forming three parallelograms of force. It will be observed that as we

Fig. 17.—Master model from combination impression of compound and "dentocoll." Cuspid and lateral incisor have been cut off in anticipation of extraction. All work was done on duplicates, diluted dentocoll in a double boiler and a duplicating flask being used. The first duplicate goes on the articulator.

change the resultant line of force at different angles from the line *O-B′*, moving around to the line *O-X*, the horizontal component, as represented by the length of the lines *f″*, *f′* and *f* is constantly increasing; that is to say, beginning at the line *O-B′*, the value of the horizontal component is zero; and at 30 degrees, shown by the line *O-A″*, the horizontal component, the line *f″* has a value of 50

per cent of the applied force, this being true because the line *f″* is just half by measurement the length of the maximum *O-X;* and at 45 degrees, represented by the line *O-A′*, the horizontal component, line *f′* has a value of 70 per cent of the applied force, being 70 per cent as long as the line *O-X;* and, at 60 degrees, it has a value of 86 per cent of the applied force; and as the resultant line of force moves around to coincide with the line *O-X*, the applied force becomes maximum, or 100 per cent, all being exerted at right angles to the undercut. In other words, here is a case of a bar clasp at this maximum efficiency angle of approach where the entire force of dislodging traction along the line of withdrawal of the case, up to the yielding point of bending of the bar arm, is all converted to the component force which pushes directly at right angles toward the undercut plane; whereas, if it were a horizontal clasp, the same traction force would be converted by the inclined plane of the undercut to an upward and outward thrust characteristic of drag type clasps, to deflect the clasp arm outward, instead of a thrust upward and inward. The force against the undercut to retain the case increases from zero along the line of the plane of the undercut, proportionally to the angle of approach to that plane, until it reaches a maximum when at right angles to that plane, when both components, the slippage force and the retentive force, coincide and push headlong at right angles to the undercut plane. When the line of force is nearly parallel to the line *O-B*, the horizontal component is practically zero, and the vertical force or component, line *F″* is at a maximum; while, when the applied force is nearly parallel to the line *O-X*, the force for slipping is nearly zero and the force for retention is at a maximum. The variation in the applied force through the various angles is in ac-

Fig. 18.—Second duplicate model on which design is planned.

Fig. 19.—Preliminary collective test of clasp and clasp bearing areas, using No. 7 metal, various gages of spring brass wire and soft solder, tacking the surplus clasp wire to the baseplate at two places, starting with one clasp and proceeding to the next, bending the clasps with round pliers and fitting the bearing points with stones, to determine the best bearing points, types of clasps and collective action of assembled clasps, best line of insertion and troublesome points of interference to be accommodated, as a guide in waxing the casting model.

cordance with the sine proportion of trigonometry; that is, the sine value (the side opposite the angle of incidence divided by the hypotenuse), and the length of the lines *f''*, *f'* and *f* represent the measure of resistance to slippage; while the cosine value (the side adjacent to the angle of incidence divided by the hypotenuse) represents the measure of slippage force. This technical analysis should serve to prove the fact even without the necessity for tests.

A schematic exaggerated illustration of the comparative action of the two types of clasps is shown in Figure 3. In the drag type clasps, dislodgment force can produce only an outward bending of

Fig. 20.—Case shown in Figures 18-19, front view. The right angle approach of the improvised clasp bars is to be noted.

the arms as the clasp passes the bulge, even with ice-tong barbs, because, unlike ice, they cannot penetrate the enamel; whereas, in the push type bar clasp, with proper angle of approach, or some degree thereof, it takes more force to negotiate the bulge, because, owing to the angle of approach, the component force pushing toward the plane of the undercut is greater, and, especially in the bar clasp with the tapered wrist portion, there is a force operating to make the bearing points tend to turn in toward the axis of the tooth, and therefore to grip the tooth tighter as it mounts the bulge.

The effect of surface area of the bearing point of the clasp on retention and stabilization is shown in Figure 2*A*. With a more extensive foot-shaped bearing surface exactly fitting the undercut surface, as the bar clasp bends outward in passing the bulge, only the lowest point of the bearing surface remains in contact with the tooth. Therefore, as far as retention is concerned, there is really no difference from that of a rounded point bearing surface. Therefore, in whatever tests have been made, the rounded ball point has been used, the element of friction of the bearing point or surface being the same, regardless of size or shape. The

Fig. 21.—Sticky wax built up on master model to form platform of wax wherever relief from model is desired in casting, preparatory to making duplicate casting model.

larger foot-shaped bearing surfaces can be used to good advantage either as skids to facilitate dislodgment in deep undercuts where tripping action without them would be too severe, or to increase stabilization against a rocking tendency.

EFFECT OF TORSION ON TRIPPING ACTION

The effect of torsion in a clasp of spiral shape or with curvatures in more than one plane, tending to make the bearing point slip laterally to evade the undercut, should also be kept in mind. The effect

of torsion is much as if the case were retained by small upright coil springs instead of bars. It tends to lessen any tripping action, an effect that can be overcome, of course, by keeping the proximal portions of the bar uprights heavy so that all flexion will occur in the final or peripheral end, where any necessary bends should be confined to one plane to insure the stumbling or tripping effect.

RESULTS OF TESTS (FIG. 8)

A series of tests, made in as simple a manner as possible, to avoid error due to extraneous conditions, in order to determine the proportionate resistance to dislodgment force of the drag and push types, seem to support this theory without exception and to show a similar gradation in values for retention as set forth in the mathematical analysis. A perfect hard steel cylinder was used to represent the tooth bulge and an oil-tempered spring steel, bent into form without drawing the temper, to preserve its elastic limit, for the clasps, clamping the crossbar portion to a wooden block to insure bending in the uprights only. The same clasp was used in both the push and the drag tests. The force required to pass the bulge in each direction was measured by weights, showing the difference in percentage; first, fixing the cylinder to the bench and hanging the weight on the clasp for the pull test, and then reversing the process by fixing the clasp to the bench and hanging the weight on the cylinder for the push test. In no case has there been a failure to get a differential in favor of the push type, except where the bar uprights were vertical or parallel to the side of the tooth. (Fig. 9.) The range of percentage difference was from 0, when the uprights were vertical or parallel, to 143 when the uprights converged at right angles to the infinitesimal plane of the resisting surface of the cylinder, depending on the various factors covered. These tests also proved that in clasps with narrower bases, making impossible the ideal right angle approach, comparable to the more vertical uprights, the introduction of the wrist bend to get the right angle approach increased the differential of the push test over the drag test approximately 20 to 50 per cent, the differential due to

Fig. 22.—Waxed and sprued casting model, waxing on raised platform produced by previous step (sprued through back of model).

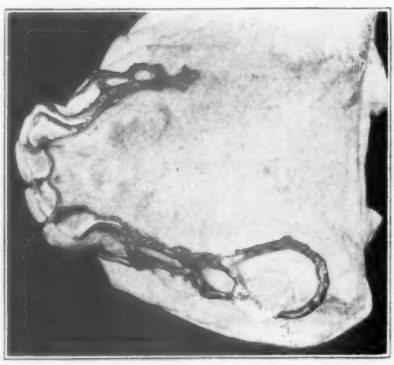

Fig. 23.—Finished casting ground and fitted to duplicate model. The angle of approach of the clasp bars is to be noted.

this wrist bend growing less as the uprights become parallel by narrowing the bases of the clasps.

The effect of a combination of a horizontal clasp on one side of a tooth, with a bar clasp on the other is shown in Figure 10. A test has also been made of a clasp with one vertical upright, representing a horizontal clasp arm, say on the lingual surface of a tooth, and the other bent to approach the undercut at right angles, to represent a bar clasp on the buccal side of the same tooth. This showed a differential in favor of the push test, indicating tripping action, but less than that of the clasp where both arms approach at right angles. The inference to be drawn from this is that if a horizontal clasp is used on one side of a tooth only, with a bar clasp on the other, the horizontal arm should be stiffened in compensation.

Fig. 24.—Case shown in Figure 23, side view.

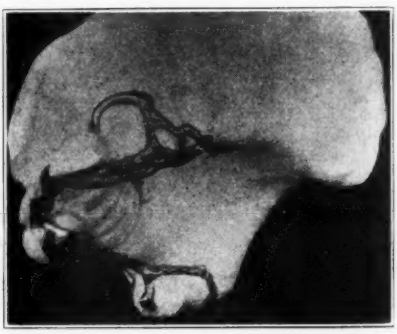

Fig. 25.—Case shown in Figures 23-24, opposite side.

The tripping action operates even on hard, smooth, parallel and lubricated surfaces, void of undercuts. (Fig. 11.) A test has also been made of the action on a piece of smooth, lubricated parallel-sided glass, instead of the cylinder representing the bulge. In this test, the clasp is given just enough tension to sustain the weight of the glass on the push test, the base of the clasp resting on the table, and then when the clasp and glass are inverted, and the clasp slowly lifted, the clasp fails to sustain the weight of the glass on the pull test. The inference to be drawn here is that tripping action operates on perfectly smooth, parallel and lubricated surfaces and should be helpful on teeth lacking undercuts, especially in stabilization against rocking movements. Of course, it may be questionable whether this delicate difference is of any practical value, but it must be admitted that it is a severe test of the theory, and should establish tripping action as something definite.

TYPES OF TEETH NEEDING BENEFIT OF FULLEST MEASURE OF TRIPPING ACTION

Two types of cases present difficulties: First and most commonly perhaps, the short tooth where undercuts are hard to find or lacking entirely, either anatomic or positional (where a tooth lacking an anatomic undercut may provide a positional undercut with reference to reciprocating clasps on other teeth). It is in this type that it becomes advantageous to spot

the clasp bearing point in the most effective place and introduce tripping action to the fullest extent by aiming the upright directly to this spot if possible, or if not, putting in the wrist bend where it arches over the gingiva to supply the right angle approach and stiffening the elbow portion. Eye bars aimed directly at right angles to slight gingival undercuts on the lingual side of the upper bicuspids and molars and on the distal aspect of the last upper or lower molars, where they just naturally have the right angle approach, exert very positive tripping action. Before waxing these, it is wise to carve the casting model slightly at the bearing point to provide excess for finishing on account of the restricted possibilities of adjustment. As it has been shown that tripping action acts to a slight extent even on parallel surfaces, it would seem discreet to choose the bar clasp in these short teeth lacking undercuts.

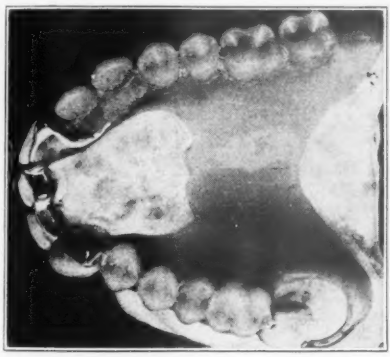

Fig. 26.—Finished case, thermoplastic base, back on same model.

Fig. 27.—Case shown in Figure 26, side view.

TYPES OF TEETH REQUIRING REDUCED TRIPPING ACTION

Secondly, there is the long bell-shaped tooth type, perhaps with extensive gingival recession, or excessively inclined teeth, and here the problem is reversed. It is a question of keeping out of the undercuts. A combination of the two types could be used, one on each side. Dr. Roach obviously designed the C bar for this type, torsion and the offset preventing too severe tripping action to facilitate removal. The DeVan saddle-embrasure clasp successfully harnesses the deep undercuts on the mesial and distal surfaces of bicuspids, cuspids and molars, and manages to avoid the difficulties of excessive tripping action by having the bearing points contact the tooth high in the undercut and then directing a barb-like extension gingivally around the mesiobuccal or distobuccal angle, which could be made to serve to lessen the difficulty of removal from a deep undercut by acting as a skid which tends to deflect the bar laterally in passing the bulge to minimize too severe tripping action.

EFFECT OF TRIPPING ACTION ON STABILIZATION (FIG. 12.)

We have thus far considered the effect of tripping action on retention in resisting dislodgment when the case is lifted off directly. As a matter of fact, dislodgment of cases in function usually or more

often starts with a tilting or rocking movement. Figure 12 shows why tripping action is even more positive and effective to prevent the very beginning of such undesirable movement, and this demonstrates how the bar clasp can improve the quality as well as increase the degree of retention, even when the spring tension on the clasp arm may be less or even out of contact, a quality depending on tripping action, and lacking in precision attachments. In the rocking movement of bilateral cases, the occlusal rests on the opposite side act as centers of rotation, and on the bar clasp side in the figure representing this rotative move-

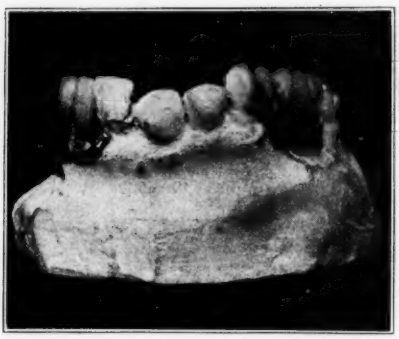

Fig. 28.—Case shown in Figures 26-27, front view. The angle of approach of the clasp bar is to be noted.

ment, the curved line of withdrawal has the effect of increasing the angle of the undercut plane to more nearly right angles to the long axis of the bar, which bearing head on is prevented thereby from bending, and therefore more effectively stabilizes against rocking movement by blocking it at its inception. Of course, this curved line of withdrawal has the effect of increasing the angle of the undercut plane in the case of the horizontal clasp, but it should be remembered that the horizontal clasp bends outward more easily than the bar clasp for the reasons already given, Figure 12 illustrating more graphically how the bearing surfaces are parallel to its long axis.

STABILIZATION AGAINST LATERAL THRUSTS OF OCCLUSAL FORCES (FIG. 13.)

The vertical force of the bite is converted with little loss by the inclined planes of all supplied artificial teeth to a horizontal component thrust which is delivered to the abutments to move them laterally, and as stabilization by a rigid, unyielding appliance must necessarily in-

Fig. 29.—Sticky wax relief platform built up preparatory to making duplicate casting model.

crease the load on the abutment, consideration should be given to the comparative stabilizing action of bar clasps versus horizontal in connection with this lateral thrust both from the standpoint of making the appliance rigid to prevent lateral shift, and also from the standpoint of how the abutment can best take this increased load. With reference to making an appliance rigid, the assumption that a stiff cast horizontal clasp will better stabilize

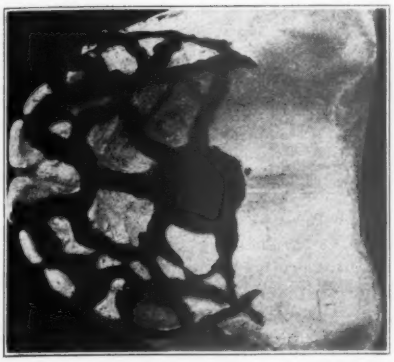

Fig. 30.—Casting model waxed and sprued through back of model. The part of this waxing that will be anchored midway in the vulcanite or baseplate has been laid directly on the raised platform created by the previous step.

Fig. 31.—Finished casting fitted to duplicate model. The angle of approach of the bar clasp is to be noted. The boxed rest is in the inlay in the right central incisor. The interrugae groove on the model was deepened before the pattern was waxed. The part to be anchored in the baseplate now stands clear from the model.

a case to resist this lateral thrust than a bar clasp will be seen to be an illusion when it is realized that, relevant factors being equal, the bar clasp, in one respect, can be even more effective because it takes

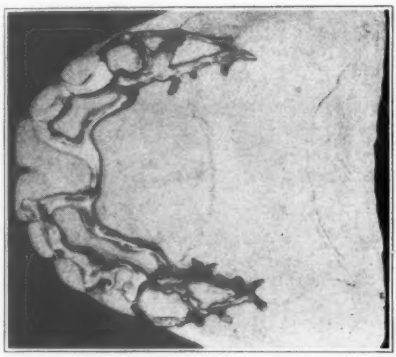

Fig. 32.—Case shown in Figure 31, occlusal view. The angle of approach of the bar clasps is at right angles to the undercut plane.

Fig. 33.—Case shown in Figures 31-32. The angle of approach of the bar clasp is to be noted.

the load of bending force more in line with its long axis, which prevents bending. Also, this extra stabilization can be obtained by the bar clasp with less strain on the supporting structures of the abutment tooth because the tooth takes the load nearer the gingiva, thereby lessening the leverage, the stiff portion of the horizontal clasp being near the occlusal level, which increases the leverage. In the case of the bar clasp, this would require an occlusal rest that would permit a slight

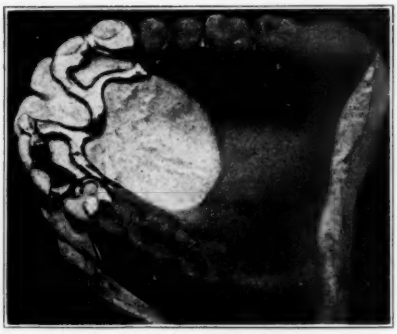

Fig. 34.—Case shown in Figure 33; finished with thermoplastic.

Fig. 35.—Case shown in Figure 34, opposite side. The right angle approach of the bar clasp is to be noted.

lateral shift. It would seem that the importance of this factor would indicate that clasp bearing points should be as near the gingiva as possible in using bar clasps. And as shown at the right in Figure 13, there is also the possibility with the bar clasp of going to the other extreme and permitting a certain amount of stress-breaking action by lighter, tapered uprights in combination with an occlusal rest on a flatter seat to permit lateral shift, if such be desired, and the occlusal rest would transmit stress only parallel to the long axis of the tooth. Of course,

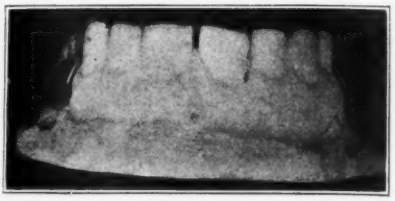

Fig. 36.—Case shown in Figures 34-35, front view. The angle of approach of the bar clasps is to be noted, as well as the space between the central incisors, which it was necessary to circumvent.

Fig. 37.—Method of making preliminary survey beforehand on study model to test collective action of assembled clasps, types of clasps to be used and their best bearing points on the teeth; how far beyond the widest convexities they may go to advantage, the most advantageous line of insertion and withdrawal of the whole denture and the sequence of engagement of undercuts; the most troublesome points of interference to be accommodated, and the extent of probable movement of movable saddles; to be used as a guide in waxing the case. This can be prolific of constructive ideas at the time most needed and should help to prevent error before it is too late. The spring brass wire clasps and occlusal rests are soft soldered to metal baseplate, No. 7, chloride of zinc flux and wafer of soft sponge rubber attached with sticky wax under movable saddle.

if stabilization is paramount, the bar upright should be stiff enough to carry the burden of lateral shift in order that the occlusal rest may be spared from this lateral thrust at the higher level.

CONTRAST OF TWO TYPES IN TRANSMITTING UNDESIRABLE STRESSES TO ABUTMENTS

The question might arise as to whether this extra spreading tension referred to between the occlusal rest and bearing point of the bar clasp, caused by the increased resistance, due to tripping action, would not tend to tilt the tooth. While theoretically this might happen, practically it has not been observed to create

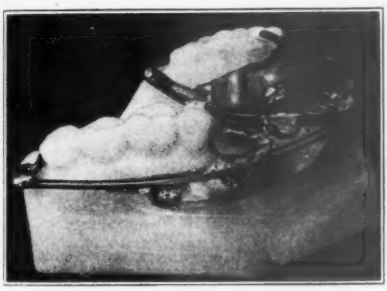

Fig. 38.—Case shown in Figure 37, side view. The angle of approach of bars is to be noted.

such an effect. No doubt, a condition of equilibrium is soon established, so that this force does not operate during the resting phase, and comes into play only when the case begins to lift. In other words, it is an intermittent and not a constant force. Of course, under any exaggerated condition, any possible undesirable tilting movement could be prevented by using both mesial and distal occlusal rests to provide full reciprocation. In this connection, the greater forces to cause undesirable tooth movement are due to the biting thrust in the opposite direction.

DeVan has made a significant observation concerning the possible comparative effect of the two types of clasps on undesirable tooth movement. He has classified the orthodox circumferential clasp as a suprabulge type, traversing in almost its entirety the inclined surface above the greatest diameter of the tooth, and the bar clasp coming from the alveolar process as an infrabulge type, which nowhere makes contact with the same inclined surface; and where there might be unequal tension in reciprocating arms, the occlusal thrust in the case of the horizontal

Fig. 39.—Case shown in Figures 37-38, opposite side.

clasp, exerted directly to the suprabulge inclined surfaces, might cause undesirable horizontal stresses; and this, of course, does not occur with the bar clasp entirely on the gingival side of the bulge. Chapelle has also observed the possibility of unequal stresses between reciprocating arms of a circumferential clasp in transmission of occlusal forces.

COROLLARY SIGNIFICANCE OF THEORY

This theory is all simple and elemental,

and the fact that the theory and tests are confirmed is perhaps nothing to get excited about. But the corollary based on this theory is portentous: That tripping action, reciprocating tripping action, introduced wherever possible all around a case, improves retention and stabilization, not only in degree, if desired, but, what is even more significant, also in quality, by reversing the direction of slippage tendency to produce that snug, solid, snap-in, staying effect, so acceptable to the patient, so compatible with physiologic requirements and so mechanically

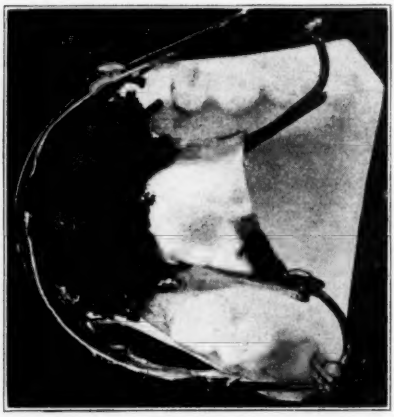

Fig. 40.—Clasp detached and upside down to show sponge rubber cushion.

efficient in mastication. In cases wherein partial dentures must be used, it will go far to reduce the handicap common to fixed bridgework. It will provide a quality of retention that does not obtain with any internal box type precision attachment; but this is not to disparage the value of the precision attachment. With all this, it makes unnecessary such severe clasp arm tension on the teeth as the horizontal clasp arm must exert to make the most of its last chance to hang on. If the denture starts to lift or rock, the reciprocating tripping action makes it cling all the tighter, so that any tendency to slippage is always toward the seat of the denture. This same tripping action operates even more positively in stabilization to resist rocking movements definitely at their inception, those movements in function which initiate most dislodging forces, and all this with less damaging lateral thrust on the abutments. This is what is meant by quality. In cases wherein a certain amount of mobility is desired, the longer more tapered bars can be made to provide a more loosely fitting prosthesis, which will continue to be retained even with such reduced spring tension as would render a circumferential clasp functionless. It is commonly observed that after partial dentures are worn for a time, there is more or less of what might be termed loose motion and that they are not so tight as when first installed. It is when this stage has arrived that tripping action of all the clasps collectively would contribute to retention and stabilization, even if all the bearing points were not at all times in contact with their bearing surfaces because of the reversed direction of the slippage tendency.

The first impression seems naturally to be that provided the same undercut is engaged with the same spring tension and length of clasp arm, there should be no difference as to how it is approached, and that this claim for the superiority of the bar clasp is making a mountain out of a molehill. Here, let it be asked: Does a knowledge of direction have any bearing on where you wish to go? Has the set or pitch of a tool any influence on its working effect? Would you attempt to push a baby carriage up the steps forward, or a wheelbarrow over the curb, instead of turning around to pull them up backward? Why is it that this same fundamental principle, which we instinctively

take advantage of so naturally in everything else in life, should be so abstruse and should have been overlooked for so long in its application to clasp design? It would seem to be the failure to visualize the fact that the sides of the tooth are really parallel to the long axis of the horizontal clasp arms.

It is my conviction that, as far as reducing the many natural and inevitable limitations of dentists in the restoring of crippled mouths of patients is concerned, especially in view of the many vacancies left as a result of our inability to solve the root canal problem, and the ravages of periodontal destruction, in so many cases, all of which increases the number of partial denture prospects to perhaps first place for all cases that require dental service, this effect of reversing the direction of slippage tendency and blocking rocking movements before they begin, through tripping action, will improve the efficiency of an acknowledged inadequately served branch of prosthesis where most sorely needed.

SOME OF THE PHYSICAL PROPERTIES OF PLASTERS AND STONES

By MAURICE A. GOLDBERG, D.D.S., Washington, D. C.

THIS work was undertaken for the benefit of the several departments of the Georgetown University Dental School, to determine some of the physical properties of the various dental materials, to be used as a guide in purchasing. This report deals with plaster, both model and impression, and stones. No effort was made to find any previous works of a similar nature in the dental literature, as it was felt desirable that this work be carried on independently of previous data.

Four each of the better known impression plasters, model plasters and stones were purchased on the open market. One stone, submitted by a manufacturer, was tested along with the others. These were tested for setting time, temperature rise, dimensional change and tensile strength. Crushing strength tests were not made, owing to a lack of equipment. Strength values may be assumed from the tensile strength results. The testing consistency of each material was established before proceeding with each test, and all of these were made in triplicate, the average result being taken. Mechanical spatulation was used throughout, except in tests on one stone. Time was accurately governed by the stop watch. All tests were made at room temperature, which ranged between 78 and 82 F.

CONSISTENCY

The information furnished by the manufacturers for the proper proportions of these materials to be mixed with water is lacking in detail. Some of them give proportions by weight and some by volume. With the exception of one stone, no exact directions are given in terms of measurements that can be easily followed by the average practitioner.

The testing consistencies used in these tests were arrived at by the "slump" test method, which is used for investment

Name	Consistency			Temperature Rise			Setting Time		Dimensional Change		Tensile Strength		
	Powder	Water	Ratio	Degrees	No. of	Rise	Initial	Final	Linear Expansion	Time of Maximum Expansion	Pounds per Square Inch		
Model Plaster	Ounces	C.c.	Ounces to C.c.	F.	Minutes	Per Minute	Minutes	Minutes	Per Cent	Minutes	7 Days	2 Hours	1 Hour
A	3.0	48	1 16.0	21.3	16.6	1.28	15.00	29.0	0.2161	24.0	696.40	409.72	382.02
B	2.5	43	1 17.2	17.0	12.0	1.41	11.00	22.0	0.240	22.6	557.89	363.99	363.99
C	2.5	58	1 23.5	23.0	10.0	2.30	8.00	22.0	0.136	15.0	282.54	144.04	171.74
D	2.0	50	1 25.0	19.0	10.0	1.90	10.50	*	0.185	28.3	282.54	†	†
Impression Plaster													
AA	2.0	50	1 25	18.0	5.5	3.27	3.30	11.3	0.1135	8.3	337.94	144.04	144.04
BB	3.0	53	1 17.6	33.5	5.5	4.78	3.30	5.3	0.117	6.0	467.02	337.94	318.55
CC	2.5	60	1 24.0	24.0	6.5	3.69	3.75	5.3	0.162	9.0	373.85	144.04	171.74
DD	2.0	58	1 29.0	15.0	7.5	2.0	6.75	*	0.167	16.3	171.74	†	†
Stone													
AAA	4.0	41	1 10.2	21.0	13.0	1.61	9.00	11.0	0.121	21.6	1213.54	587.24	794.99
BBB	4.0	41	1 10.2	33.0	13.0	2.53	11.50	14.0	0.123	22.0	1056.45	681.42	531.84
CCC	4.0	27	1 6.7	28.0	21.0	1.33	11.00	15.0	0.175	28.3	1130.44	759.26	587.24
E	4.0	41	1 10.2	31.0	12.0	1.58	10.50	12.0	0.079	19.3	975.04	476.44	282.54
F	4.0	41	1 10.2	29.0	12.0	1.23	8.00	10.0	0.113	21.0	789.45	501.94	493.06

*Over sixty minutes.
†Less than 144.04 pounds per square inch.

materials.[1] A cylindrical mold 2 inches long, with an internal diameter of $1\frac{3}{8}$ inches was filled with a mix, and lifted after two minutes, the material spreading over a glass plate. One minute later, the spread was measured. Mixes of varying proportions were tried until the mix producing an average measurement of the maximum and minimum diameters between $2\frac{1}{4}$ and 3 inches was obtained. A deviation from this method was made in the case of the impression plasters. Owing to their rapid setting, the mold was lifted one minute after the mix was started.

The powder:water ratio varies widely for both the model and the impression plasters. To obtain a mix resulting in the proper spread necessitated using greater quantities of water, in some cases, the necessity manifesting itself in many ways. The powder:water ratio for the model plasters was from 16 to 25 c.c. of water to 1 ounce of plaster, and from 17.6 to 29 c.c. of water to 1 ounce of impression plaster. Four of the stones required exactly the same proportions of powder and water, as shown in the accompanying table. In the case of stone CCC, the amount of water used was considerably less, the powder:water ratio being 1 ounce to 6.7 c.c. The mix using these proportions was so stiff as to make mechanical spatulation impossible; even hand spatulation being difficult. It was found that sharp vibration thinned the mass, so that after about one minute of mixing and jarring, it was quite plastic. The manufacturer's instructions in this case are to add 100 gm. (3.5 ounces) of powder to 27 c.c. of water and mix to a putty-like consistency. Using these proportions and mixing and jarring as described produced a mix which spread entirely too much when the mold was lifted after two minutes. The powder content was therefore increased until the desired consistency was reached.

1. Taylor, N. O.; Paffenbarger, G. C., and Sweeney, W. T.: Dental Inlay Casting Investments, J.A.D.A., 17:2266 (Dec.) 1930.

TEMPERATURE RISE

The heat generated during the setting of these materials was ascertained by the simple method of inserting a thermometer in a mix and recording the temperature rise against time.

Both the rise in temperature and the time consumed varied for the materials in each group. It is interesting to note that the model plaster A and the stone CCC, which took up the greatest quantity of powder, that is, the heaviest mix, took the longest time to reach the maximum rise in temperature, as shown in the accompanying table. This is not true of the impression plasters, although BB, which produced the heaviest mix, had the highest rise in temperature. This material reached quite high temperatures, going as high as 119 F., which brings to mind the case of a dentist who scorched both the upper and lower oral soft tissues with impression plaster and caused the patient two weeks of intense suffering.

SETTING TIME

The time of set was determined by the use of the Gilmore needles.[2] The small needle having a weight of one-quarter pound and a point one-twelfth inch in diameter was used to indicate the "initial" set, and the large needle, weight 1 pound, point one-twenty-fourth inch in diameter, was used to indicate the final setting time. The mix was poured into a ring one-half inch wide, and 3 inches in diameter. The point of the small needle

2. Goldberg, M. A.: Dental Materials: A Didactic Subject, D. Digest, 40:282 (Aug.) 1934.

was made to rest upon the surface of the mix from time to time until no impression was left by the point. This was taken as the time of initial set. The large needle was used from that time on, in the same manner, for the final setting time.

Both the initial and final setting times will be seen on the table to vary for all three groups of materials. An interesting observation is that model plaster D, and impression plaster DD, produced by the same manufacturer, and both the thinnest mix in each group, failed to reach the final set in one hour. Paradoxically, it may be noted that stone CCC, having the heaviest mix of the stones, took the longest time to reach the final set. Model plaster A and stone CCC, both the heaviest mixes in their group, and with the longest time of final set, took longest to reach the maximum rise in temperature. This is not true of impression plaster.

DIMENSIONAL CHANGE

Dimensional changes were determined by means of a comparator microscope apparatus, as is used for investments.[3] The equipment used for these tests is an improved model.[2]

In each case, there was an expansion or increase in length. In each case, the maximum expansion was reached after a period of time, and remained at that point. In only one or two cases was there a slight contraction after twenty-four hours. Consistency obviously has no relation to the expansion of these materials, although it may be noted that model plaster D and impression plaster DD, both the thinnest mix, took the longest times to reach maximum expansion. Another interesting observation to be made regarding any relationship is in the case of stone E. It would seem logical to assume that since this material has a lower expansion than all the others, the degree temperature rise per minute, and the time consumed in reaching the maximum expansion, should be proportionately lower. This is not true, although the time of maximum expansion in minutes is lower than for the other stones.

TENSILE STRENGTH

The equipment used for these tests consisted of clamps for holding the specimen, a bucket for holding the weights and a die for obtaining the samples.[2] The sample was placed in the clamps and attached to the bucket by means of chain, and weights were added until rupture occurred. Samples tested were 1 hour, 2 hours and 7 days old. As has been previously stated, crushing strength tests were not made. The values obtained from tensile tests give an indication of the strength of the materials.

In the cases of both the model and the impression plasters, the heaviest mixes, A and BB, are the strongest, while the thinnest mixes, D and DD, are the weakest. In fact, the weight of only the bucket and clamp was too much for the latter plasters on samples both 1 and 2 hours old. It would seem reasonable to expect stone CCC, the heaviest mix, to be the strongest of the stones, but this is not true. It is interesting at this point to note that model plaster C, impression plaster CC and stone AAA are stronger the first hour than the second; and that model plaster B is no stronger the second than the first hour. Furthermore, there seems to be no relation between temperature rise and setting time as to strength, except in the case of model plaster A.

SUMMARY

It is obvious, after consulting the table of results of the tests made on these ma-

3. Coleman, R. L.: Cast Materials, D. Cosmos, 68:743 (Aug.) 1926.

terials, that some of the model and impression plasters are not satisfactory from the point of view of the purpose for which this work was intended.

Exact instructions for the proper proportions of plaster or stone to be mixed with water are not given in a manner which can be followed by the practitioner.

Some plasters and stones generate too much heat for the comfort of the oral soft tissues, or for safety if used in connection with other materials that are softened by heat.

The time of initial set seems to be sufficient for the purposes to which these materials are put, but the final setting time of some of them is undesirable.

Expansion occurs in each case, and in most cases is not too great.

The model and impression plasters requiring the heaviest mixes seem to be the strongest. It appears, in most cases, that there is sufficient strength after one or two hours for the usual prosthetic operation.

Specifications could and should be established for these materials, and an attempt should be made to standardize them.

DENTURE MATERIALS

By GEORGE A. HUGHES, D.D.S., San Francisco, Calif.

THE purpose of this paper is to present to the general practitioner the results of clinical and laboratory observations regarding the working qualities and general clinical behavior of present day denture materials. There has been so much high pressure advertising on the part of the manufacturers in favor of these new denture bases and so much disappointment following their use that many dentists have come to regard all such materials as equally untrustworthy. This stand on the part of the dentists is no doubt quite justified, as each new material has been proclaimed by its sponsor to be the ideal denture base. It is true that many present day denture bases are fit only to be used as temporary bases, if at all, but others, if correctly handled and a knowledge of their properties applied, will render valuable service, where indicated.

Many papers have already been written and published on this subject, but, for the most part, they may be classed in two groups: (1) those obviously prejudiced in favor of a particular manufacturer's product and (2) those written from a scientific standpoint and filled with information as to tensile strength, ultraviolet light index, elongation, absorption index, specific gravity and many other data of great interest to research workers concerned with creating such materials. The first type of article is misleading, and the second seldom read by the average dentist and of little use to him if he does go to the trouble of reading it.

In this paper, I have attempted to present the findings in such a manner that every one may know the difference between the various materials and also what may be expected after the use of any present day plastic denture bases.

In order that we may know them, these

materials must first be classified. All of our bases fall into one of two major divisions: (1) metals and (2) plastics. The first division is subdivided into two groups, precious and nonprecious.

As the materials in the first group are relatively seldom used and their qualities are commonly understood, and as most of the materials in question are in the second division, I shall confine this paper to those materials classed as plastics.

It is well at this time to differentiate between the materials in the plastic group. There are two types: (1) thermoplastics and (2) thermoset plastics. This terminology is based primarily upon the method of fabricating the material into a denture. The thermoplastic bases are heated to render them plastic and are then forced into shape by means of pressure applied in a suitable press. All of the materials in this group are hampered by two great difficulties: (1) unless sufficient heat is applied, they do not become plastic enough to be molded without dimensional change and (2) if sufficient heat is applied to develop the required plasticity, the color is frequently impaired. The thermoset plastic bases are placed in molds in a plastic or granular state. Very little pressure is used to effect closure of the flask and heat is then applied to cure the materials. (Table 1.)

In the thermoplastic group, all of the cellulose base materials are placed, such as: celluloid, hecolite, agalyn and parfait. In the same group would be placed one type of synthetic resins, the vinyl resins, such as resovin and vydon.

In the thermoset plastic group are placed vulcanite, the phenol-formaldehyde synthetic resins, such as iteco,coedal, cooralite and luxene, and also the glycerine base resin, glycene.

Having classified the materials for a more comprehensive understanding, let us consider the conditions that have a direct bearing on the working qualities and clinical behavior of these materials. These may be grouped into several sections: (1) those pertaining to the appearance and comfort of the patient, (2) those pertaining to oral health and service and (3) those pertaining to technical aspects. Under the first section, the following are listed: appearance, odor-taste, thermal conductivity and weight.

TABLE 1.—DENTURE MATERIALS

- I Metals
  - A. Precious
    1. Gold and alloys
    2. Platinum and alloys
    3. Palladium and alloys
  - B. Nonprecious
    1. Vitallium
    2. Stainless steel
- II Plastics
  - A. Thermoplastics
    1. Cellulose
       (a) Celluloid
       (b) Hecolite
       (c) Agalyn
       (d) Parfait
    2. Vinyl resins
       (a) Vydon
       (b) Resovin
  - B. Thermoset plastics
    1. Vulcanite
    2. Phenol-formaldehyde resins (condensites)
    3. Glycerine base resins—glycene
       (a) Iteco
       (b) Coedal
       (c) Cooralite
       (d) Luxene

Under the second section are listed: tissue tolerance, color life, strength, stability of form, structural adhesion, density and reparability.

Under the third section are listed: special equipment needed (other than the standard vulcanizing equipment), cost, time required in fabrication, precisional qualities (under average conditions) and technical skill required for successful manipulation.

Following the foregoing, a chart has been prepared and the various groups of

TABLE 2.—DENTURE MATERIALS

Type	Appearance, Comfort				Oral Health, Service							Technical					Summary		
	Appearance	Odor—Taste	Thermal Conductivity	Specific Gravity	Tissue Tolerance	Color Life	Strength	Stability of Form	Structural Adhesion	Density	Reparability	Special Equipment	Cost	Time Element	Precisional Quality	Skill Required	A	B	C
Vulcanite	C	B	C	C	B	A	B	A	A	B	A	A	A	B	B	B	6	7	3
Cellulose	B	C	B	B	B	C	A	C	C	C	C	B	B	A	C	A	3	6	7
Condensite	A	A	A	B	A	B	C	A	A	B	B	A	B	B	A	B	8	7	1
Vinyl resins	B	A	B	A	A	A	C	A	B	A	B	C	B	B	C	B	6	7	3
Glycerine resins	B	A	A	B	A?	A?	B	A	A	A	B	C	C	C	C	C	7	4	5
Vulcanite—condensite facing	A	B	C	C	B	B	B	A	A	B	A	A	B	C	B	B	5	8	3

impression materials have been listed or graded according to their relative merits, as A, good; B, fair; C, poor; the group or groups having the highest rating in each individual factor or property being rated as A, and the remainder being rated according to their relative merits for the same property. An A rating, therefore, merely indicates that the material is the best available for that particular property at the present time. It is not intended to indicate or assume in any way that the material is ideal.

Table 2 affords much interesting information. Some of the more evident is that:

1. Vulcanite has a reasonably high score of A's and B's, these scores being found mainly in the last two classes of conditions. Hence, we may conclude that no other material ranks so high in those properties pertaining to durability, service and low cost of fabrication.

2. The cellulose group rank the lowest in all properties except strength and simplicity of fabrication; hence, they may be considered as unsuitable for denture materials, other than for temporary dentures, or for similar special uses. The disintegration of these materials is especially rapid in the mouths of certain persons.

3. The vinyl resins are fairly high in desirable properties, except strength and precision of the finished case. If these two factors can be improved either by changes in the technic of manipulation or in the material itself, one may expect that the denture material of the future may well be one of this group.

4. The phenol-formaldehyde group of synthetic resins or condensites, as they are commonly called, rate the highest of all materials in a general way, but seemingly have two serious deficiencies, insufficient strength and limited color life. As a matter of fact, the color life factor on the chart has been rated a little higher than the materials as a group may deserve, owing to the inclusion of luxene, the latest addition in the condensite group. It is asserted that the last named material has a color life of at least five years, and it is apparently going to live up to the manufacturer's claims. Up to the present, there has been no objectionable change in color in dentures several years old made of this material.

5. The last group on the chart, the glycerine base synthetic resins, have many desirable features; but, up to the present, have never been tested clinically, owing to apparently insurmountable technical difficulties. These materials and the vinyl resins have been found successful according to reports by a few men who seem to have consistently good results. The majority, in fact almost all others, have reported consistent failures.

6. A combination of vulcanite with a condensite facing often makes as near an ideal denture base as can be found in the plastic groups at the present time. I have found this to be especially useful on lower denture cases, where strength is of more importance than on upper dentures, owing to the structural form. This combination lends itself readily to rebasing, as the facing and rebasing can be accomplished at the same time, several desirable factors thus being obtained; namely, good color, improved tissue tolerance and strength.

CONCLUSION

It may be said that although there are many materials available as denture bases at the present time, there is as yet no ideal material. All factors being considered, vulcanite, despite its known faults, is the most practical from the standpoint of economy, service and general dependability. Vulcanite, when combined with a condensite facing, usually

presents a very satisfactory appearance, in addition to its other good qualities.

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FACIAL NEURALGIA RELIEVED BY PHRENIC NERVE BLOCK: REPORT OF A CASE*

By ANDREW L. BANYAI, M.D., Wauwatosa, Wis.

HISTORY.—J. W., a colored man, aged 35, was admitted to Muirdale Sanatorium, Feb. 5, 1934. He had whooping cough at 11 and measles at 18. He had mumps and influenza in 1919 and his tonsils were removed in 1926. In the Spring of 1932, he began to lose weight and strength, and a persistent pain developed in the left side of the face. The maximum area of intensity of the pain was in the left infra-orbital and maxillary regions, from where it extended to near the external meatus of the left ear and radiated downward to the clavicle along a path of about 2 fingers breadth, oftentimes reaching as far as the heart region. At the same time, he also had what he described as rheumatic pain in the left shoulder and arm, and a dull frontal pain near the base of the lung on the left side. He has had a productive cough since October, 1933. A pulmonary hemorrhage occurred in November and December, 1933, followed by the constitutional symptoms of tuberculosis, including fever and night sweats. At the time of his admission to the institution, he also complained of cough, expectoration and thoracic pain, but the chief complaint was the severe radiating pain in the left side of the face.

Examination.—On physical examination, the patient appeared fairly well developed, somewhat undernourished, slightly toxic and weak. Signs of an active tuberculous process extending from the apex to the base of the left lung and over the upper one third of the right lung were found. There were no murmurs over the heart, which was of normal size and location. The pulse occasionally skipped a beat, but it was found to be normal in rhythm and volume at the next periodic examination, two months later. The blood pressure was: systolic, 125; diastolic, 105. The neurologic findings were negative, except for slightly exaggerated knee jerks.

Roentgen-ray findings were: left lung: extensive parenchymal involvement practically throughout, with a cavity in the upper lobe; right lung: parenchymal infiltration extending from the hilum into the middle one-third toward the base.

The paranasal sinuses were negative on roentgen-ray examination. There was no pathologic condition in the nose. The left ear was normal. There was a chronic otitis media on the right side.

R. J. Fitzgerald, visiting dental surgeon to Muirdale Sanatorium, found no dental disease on physical and roentgen-ray examinations.

The Wassermann and Klein tests of the blood were negative. Tubercle bacilli were present in the sputum. The hematologic examination revealed a secondary anemia. The sedimentation of the red blood cells was rapid.

Treatment.—An artificial pneumothorax was established on the left side, April 27, 1934, and this treatment was continued

*From Muirdale Sanatorium.

until Jan. 18, 1935. This evidently had a beneficial effect on the general and pulmonary condition, but the patient continued to complain of pain in the left side of the face. He stated that it was a steady pain, with slight remissions and frequent agonizing exacerbations, and as a consequence he was suffering with sleeplessness. The pain was not affected by mastication, or by taking cold or hot water into the mouth.

Therapeutic external heat application and counterirritation were of no avail. The rather large doses of analgesics, in combination with sedatives, gave only a transient relief.

After the distressing failure of all medical attempts, it was thought that this intractable, rather unusual type of trigeminal neuralgia might have its origin in a diaphragmatic pleurisy and be transmitted through the phrenic nerve to the third cervical segment of the spinal cord and transmitted or relayed from there through the descending or cervical tract of the trigeminal nerve to the face.

Operation.—A therapeutic test was decided on and an operation for a phrenic nerve block was performed on the left side by Dr. Raine, Oct. 4, 1934. According to the surgical report, a typical phrenic nerve was found on the scalenus anticus muscle. The nerve was crushed over 3 clamps' breadth. The complete paralysis of the nerve was evidenced by the paradoxical motion of the left side of the diaphragm following operation and observed under the fluoroscope.

Outcome.—The patient has been free of facial neuralgia since the day of the phrenic nerve block. As he said, "I had relief from the pain as soon as I got off the operating table."

Comment.—Fluoroscopic examination of the chest after the establishment of an artificial pneumothorax on the left side revealed adhesions between the base of the left lung and the central portion of the diaphragm. These changes strongly suggest that the cause of the pain conveyed through the left phrenic nerve was a diaphragmatic pleurisy. The phrenic, besides being the motor and trophic nerve of the diaphragm, innervates its central portion with sensory fibers. It arises chiefly from the fourth cervical nerve, but receives a branch from the third and another from the fifth. The fibers of the sensory root of the trigeminal nerve arise from the semilunar ganglion and, entering the pons, divide into upper and lower roots. The lower root passes through the pons and medulla oblongata, and ends at the second cervical segment of the spinal cord.

As a rule, there is no connection between the descending or spinal branch of the trigeminal nerve and the site of origin of the phrenic nerve. I have not seen a similar case of facial neuralgia caused by diaphragmatic pleurisy during my twenty years' experience in the care and treatment of tuberculous patients. No mention is made of such an occurrence in standard textbooks on tuberculosis or symptomatology. The relief from facial neuralgia that followed the phrenic nerve block in this case strongly suggests that this is an instance of an anomalous anastomosis between the sensory roots of the trigeminal and phrenic nerves in one of the upper cervical segments of the spinal cord. The patient is free from neuralgic pain at present, seven months after the therapeutic crushing of the left phrenic nerve.

CONCLUSION

In a case of facial neuralgia, complete and permanent relief has been obtained by a phrenic nerve block. The neuralgic pain originated from a tuberculous diaphragmatic pleurisy on the left side and was referred to the second division of the trigeminal nerve, from where it radiated toward the ear and the cervical region on the same side.

STANDING VS. SITTING

By HERBERT ELY WILLIAMS, D.D.S., Red Bank, N. J.

BY conservative estimate, the standing operating position deprives the average dentist of from three to five practice years. Fallen arches and an enlarged left knee joint, known as dentist's knee, are only a few of the unnecessary penalties of constant standing at the dental chair.

Standing takes something out of the dentist which sitting does not. Calories, like electricity, are unseen, but their presence and effects are known and understood in definite terms of heat units. In standing, one burns from 15 to 20 more calories per hour than when in the sitting position, and since figures show that the human mechanism has only a certain definite number of calories to consume during life, it seems a pity to squander heat units so recklessly.

Science, too often ignored, offers much of which too little is accepted and applied. Grantland Rice says that balance contributes most to a great athlete's greatness. Experts assert that balance makes internationally recognized dancers what they are. Every dentist knows that the dentist in a balanced sitting position is more efficient than when he is standing and habitually working off-center. Pioneer designers of tilting dental chairs anticipated dental needs; otherwise, as an economic measure, dental chairs with stationary, nontilting features might prevail. It seems unwise and superfluous to make improvements of convenience, when convenience is so unheeded. As regards equilibrium, man is the most unbalanced contribution to the animal kingdom, because mentality has overbalanced primitive instinct. Time was when the use of the deadly cocain, feared by both patient and dentist alike, necessitated the prone chair position in resuscitation, but, even then, slapping the face with a cold wet towel was usually more effective in bringing color to the cheek and sense to the brain.

Ordinary fainting is often more amenable to the upright sitting posture, when the head is drawn down as near the knees as possible. Some chronic fainters have learned this trick themselves, resorting to it at the first sign of dizziness.

Emergency measures alone prompted most dentists to resort to the tilting feature on rare occasions only, rather than as a daily routine. Semireclining is always more comfortable than an upright position; recognition of which inspired the mother of invention to put rockers on chairs. Reclining is for the patient more restful, because of the more equal distribution of bodily weight and, in longer operations, the half reclining position produces drowsiness, perceptibly reducing nervous irritability. Prolonged absolute reclining converts drowsiness into sleep, as in retiring at night.

Only under unusual circumstances should a patient be subjected to sittings of one hour duration, and when he is so subjected, the chair should be well tilted back. It is surprising to what extent the rubber dam quiets the patient, just as the

bridle tames the colt. Often, the reclining pose and the rubber dam temporarily change the nervous temperament into the lymphatic type. Science dictates that fatigue is a misnomer and that our muscles are not actually tired but are poisoned by certain acids, the biproducts of fatigue. But what is there in a name when the dentist is fagged out at the day's end? And why unnecessarily poison our muscles more by standing longer?

Old practitioners who have resorted to the sitting position over a long period of years truthfully assert to the skeptically inclined that the "close of day" distress of standing at the chair all day is not nearly so apparent when the operating stool rather than shoe soles serve as a weight supporter for the busy dentist.

The anatomic construction of the human feet with their springing, lifting mechanism is more suggestive of walking than standing, while the one piece hoof of the horse seems especially built for standing. It is doubtful that human arches would ever collapse or would even give annoyance during walking alone in persons of near normal weight. If the human race was intended to stand constantly, nature would have provided four legs, dividing the weight in quarters, instead of halves. Compare, for instance, the limited supporting surfaces of the human feet with the powerful, cushion-like gluteus muscles, which were designed to relieve undue standing foot strain. Otherwise, such thick, powerful muscles would be unnecessary and Mother Nature never makes mistakes of that kind.

Steadiness being essential to his work, the eye and ear specialist adopts the sitting position. The expert rifleman makes his poorest records standing, while sitting and prone positions afford greater steadiness and assure better scores. Thoughtful observers of dental progress contend that the tiresome, unnecessary standing position contributed largely to the neglect of gold foil. Running and standing are both more fatiguing than walking or sitting. A golfer might handily play 36 holes a day with less fatigue than in standing at the first hole an equal length of time.

The time and place to acquire the sitting position is in the dental school. Many habits started in the dental schools stay throughout life.

Dental infirmaries are not planned to encourage use of the sitting position, an important consideration that has been overlooked. A professor of operative dentistry in an eastern dental school recently told me that to break some students of awkward chair habits was almost impossible. Awkward positions are out of the question with the patient tilted well back and the operator seated behind and slightly to the right, with the left arm around the patient's neck. Comfortable positions are never awkward.

Claims that standing is as restful as sitting fade once sitting is tried, and no convincing arguments can be advanced to the contrary.

AMALGAM: A DEFINITE MODE OF MANIPULATION

By CLAUDE C. CANNON, D.D.S., Fayette, Ala.

I SHALL not dwell on the various phenomena observed in the study of amalgams, except as they relate to points of vital interest to the dentist, offering such deductions as have aided materially in formulating a definite technic in amalgam manipulation. The technic is given as a part of this paper.

Amalgam, though metallic, possesses the property of workable plasticity or the capability of being easily molded, while in the cold state, into whatever shape the conditions may require, and soon to be set in a mass of great hardness. Among metallurgists, this property is considered quite marvelous.

It would not be doing justice either to my subject or to those untiring workers in the amalgam field unless I mention in the beginning the names of G. V. Black, Arthur W. Gray, Marcus L. Ward, Erman O. Scott, William E. Harper, Harold E. Tingley, R. C. Seibert, J. Ben Robinson, Benjamin Cornfeld and certain of the past and present workers at the National Bureau of Standards: N. O. Taylor, Wilmer Souder, William T. Sweeny, George C. Paffenbarger and Aaron Isaacs. The names of many others throughout the country might also be mentioned. Certain of these men have made great contributions to the study and development of amalgam alloys; while others have, through their work or writings, encouraged interest in both the clinical and the scientific phases of the employment of this material.

Owing to its nature, amalgam is peculiarly affected by every variation in its manipulation. For this reason, its study should be a thing of great concern to all of us. For some time, certain manufacturers have felt the need of intensive study in this field and have maintained a staff of able metallurgists for the purpose of bringing to light some of the obscure characteristics of amalgam. Thereby, they have been enabled to produce materials of excellent quality. The dental profession is fortunate indeed in that some of the investigations of certain of these men have been published in the dental magazines; but owing to the wide range of manipulative methods employed by the dentists, and the great susceptibility of the material to those variations, it has been difficult for us, as dentists, to uniformly bring out the possibilities of silver amalgam alloys in finished fillings.

To the dentist of today, a filling that not only serves its purpose as a proper seal, but also stands up under mastication or actual grinding service in the mouth with a minimum amount of form change and maximum resistance to discoloration, and that can be profitably produced at prevailing prices, is the thing that is desired. In an effort to determine the cause of our failures to produce this type of filling, and to learn the effects of varied manipulative procedure on the strength and wearing qualities, etc., of amalgams produced from our alloys, I began a study that has continued over a period of years, resulting in the develop-

ment of a technic whereby the strength and wearing qualities of every high silver alloy studied can be markedly increased.

The study from which conclusions have been drawn consisted of a consideration of the work done by various investigators, together with a series of comparative tests, and the placement of thousands of fillings in the mouth. Included were attrition, or grinding, tests, designed to reveal the resistance a given mix would register to the forces of actual chewing, this being one of the principal requirements. Next, flexure or combination tensile and compression strength tests were made; tensile strength and resistance to compressive forces being among the chief requirements of amalgam. Studies regarding the causes and effects of porosity, and a consideration of factors in mass hardness and surface hardness; studies in discoloration, with causes; studies in polishing, including modes, and conditions that influence luster; microscopic studies, and electrical observations in which a consideration of either galvanic or other electrical disturbances were made, with a brief con-

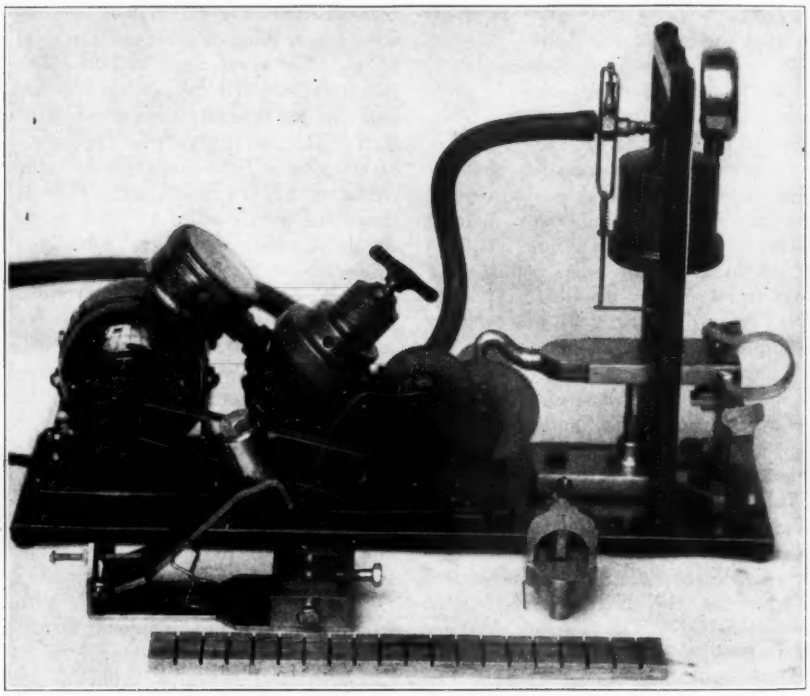


Fig. 1.—Attrition machine on which mesioclusodistal amalgam fillings placed in steel cylinders were tested, the rate of chewing or grinding strokes being 100 per minute, and duration of each test thirty minutes. The pressure under which tests were carried out was 2,000 pounds per square inch.

sideration of edge strengths, as well as other tests not mentioned. Tests were made of many mixes of the different alloys studied, various proportions of mercury to alloy being used, with different times and ways of mixing, both mechanical and hand.

It is obvious that actual comparisons of alloys, modes of manipulation, etc., could be made only where adequate control of all the factors in the behavior of the materials could be maintained. These factors are: proportions of mercury and alloy; manner and degree of amalgamation; manner and degree of condensation; size of test specimens, and the temperature from the time of mixing to the completion of the tests. In addition, adequate and properly controlled testing devices had to be used if the comparisons were to be effective. It is also obvious that if my study was to be altogether practical, the size of the test fillings and pieces, together with the mode of amalgamation and degree of condensation, and all other procedures, should be such as could be carried out in the mouth. With this study in mind, I constructed a number of machines and devices with which this investigation could be made.

One of the devices was an attrition machine, designed to give the wearing qualities of different alloys under different modes of manipulation. (Fig. 1.) This machine was powered with an electric motor and given movements that simulate those of chewing. An air cylinder with proper controls provided the great pressure that was needed in these tests. Mesioclusodistal cavities of uniform size to contain the test fillings were prepared in seven-sixteenths inch steel blocks. The

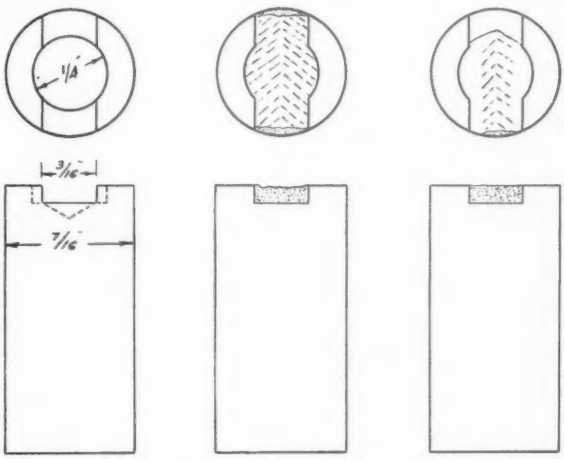


Fig. 2.—Attrition or mastication test. Left: Detail of unfilled cavity in steel block. Center: Results of attrition on amalgam when normal amount of mercury was used and normal period of mixing time. Right: Results of same degree of attrition on amalgam produced from same alloy, but with reduced mercury content and one and one-fourth to one and one-half minutes mixing time, under from 4 to 6 pounds, in mortar only, with no hand mulling. There is scarcely any crumbling and very little wear. The results were very similar for every alloy studied. The degree of condensation was the same in both cases.

attrition or grinding point of the machine was hardened steel, and oval. It was set so that it made contact with approximately half of the occlusal surface of the test filling at the beginning of the test. As the filling wore down, the contact across the occlusal face progressively increased. Thus, wear was registered both downward and across.

Another device was that for condensing these fillings and test pieces in a manner that at least approached condensation in the mouth, except for being under control, so that a desired degree of packing could be assured.

Another device was a simple but effective contrivance for applying flexure, or combination tensile and compression strength tests, designed for specimens of known size and adjusted so that the force could be applied at a given point. It was attached to the attrition machine under the air cylinder where pressure at a predetermined rate of speed could be applied, and a reading of resistance registered.

Another simple device was made for molding small test pieces of amalgam to be used in studying discoloration. These pieces received the same degree of polishing before being removed from the mold.

Another device provided means of determining galvanic or other electrical disturbances.

An incubator and other temperature controls whereby tests could be conducted at a known temperature were made, as well as other equipment needed in the study.

The purpose of this study was not comparison of the qualities of the alloys as much as comparison of various modes of manipulation, and to determine the effects of some of the common practices employed in handling amalgams. It will not be necessary, therefore, to compare the various alloys themselves, but rather to offer suggestions in practical modes of manipulation that tend to assure high type amalgam in the mouth.

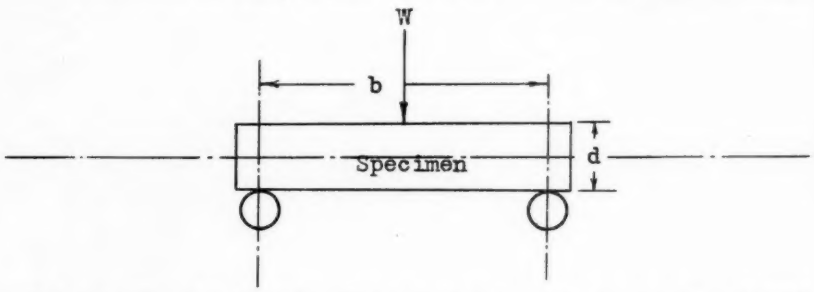


Fig. 3.—Transverse or flexure test. This type of test reveals both compressive and tensile strengths. When specimens were made under controlled conditions, this type testing showed an increase in strength ranging from 10 to 30 per cent when the mercury content was reduced and mixing carried out for one and one-fourth to one and one-half minutes in mortar, mixing pressure ranging from 4 to 6 pounds, and with 220 to 240 strokes of the pestle per minute. This increase in strength was revealed with every high silver alloy studied.

For the attrition tests, fillings of the various mixes of a given alloy, that is, mixes that were varied as to proportions of mercury to alloy and the time and ways of producing amalgamation, were placed in mesioclusodistal cavities in steel blocks, as previously mentioned. Condensation was obtained by building up

the filling in stages, very similarly to the filling of a tooth in the mouth, except that each portion was measured and condensed by a device that produced the same condensing pressure in each case, the pressure comparing favorably with heavy hand condensation. Immediately after condensing, each filling was placed in an incubator at 90 F. and kept for three hours, after which it was placed on the attrition machine for testing. The three-hour period of setting was decided on as being about the average time that elapses before fillings begin service in the mouth. The attrition was carried out at a temperature of 75 F. and at the rate of 100 grinding strokes per minute, under a pressure of approximately 2,000 pounds per square inch for a period of thirty minutes. Earlier tests of this kind had been conducted wherein hand condensation was used, and without temperature control wherein a rate of seventy-two strokes per minute and approximately 3,000 pounds per square inch were used.

These tests were carried out under rather severe pressure, but this pressure was used in order that the tests might be short. The different mixes of a given alloy, when condensing pressure was constant, crumbled and broke to varied degrees, the breaking being registered much earlier in some cases than in others. After completion of these tests, the fillings were compared and the mix that had registered the greatest resistance was selected for duplication and further comparisons. These tests showed that when a high percentage of mercury, such as a 5:8 ratio of the average high silver alloy, was used, together with light trituration, best re-

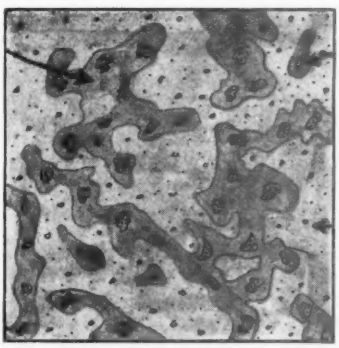


Fig. 4.—Highly plastic or very soft amalgam. Crystallization and setting of amalgam are not synonymous terms as has been believed. Crystallization is taking place in this very soft amalgam, while setting is retarded owing to the intervention of excess mercury between the granules. Thus, prolonged manipulation of a very soft mass disrupts crystallization and affects ultimate strength. Left: Arrow points to peritectic area of which it is probable Ag_3Hg_4 constitutes the greater part. Right: Arrow above points to portion of original grain of alloy. Arrow below points to area of mercury containing both tin and Ag_3Hg_4.

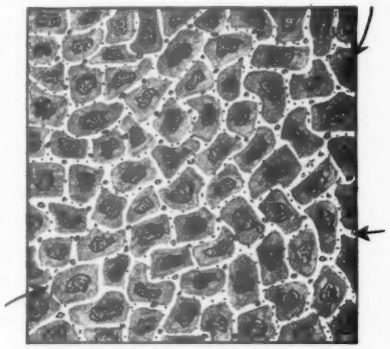


Fig. 5.—Heavily condensed amalgam. Left: arrow points to an area the greater part of which is apparently composed of the chemical compound Ag_3Hg_4, on which, it is supposed, the setting of amalgam largely depends. Right: arrow above points to portion of original grain of alloy. Arrow below points to area of mercury containing both tin and Ag_3Hg_4.

sults were obtained in approximately two and one-half minutes mixing, but that a much more resistant mass could be produced by lowering the percentage of mercury, and grinding in a 2-inch mortar for from one and one-quarter to one and one-half minutes under a pressure of from 4 to 6 pounds and at a rate of from 220 to 240 strokes of the pestle per minute, no hand mulling being carried out, condensing pressure that corresponded to rather heavy hand pressure being constant.

Duplicates of the mix that had proved best were made, and in order to learn the effect of various procedures, these were subjected to some of the common ways of handling our amalgams as carried out in everyday practice; such as, placing the freshly mixed amalgam aside and allowing enough time for sterilization of the cavity before inserting the filling. This, as we know, is a very common practice. The second duplicate was allowed to get wet while it was being condensed. The third duplicate was put aside until setting was advanced to the degree that it was necessary to add more mercury and rework the mass before filling the cavity. This is a common thing in practice, the result either of slow manipulation or of filling two or more teeth with the same mix. The alloy of the fourth duplicate was pulverized before the mercury was added in order that this effect might be studied.

Duplicate 1, with its variation, which was slight delay after mixing before filling, proved weaker, or less resistant to attrition, apparently because of crystallization before the cavity was filled. Therefore, this could not be considered a harmless procedure in dental practice.

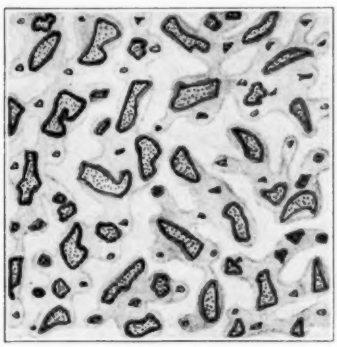


Fig. 6.—Coarse grain amalgam produced by light grinding. The irregular voids trap mercury and the condensing force does not bring the granules into close association; which probably prolongs the chemical reaction, with accompanying dimensional changes.

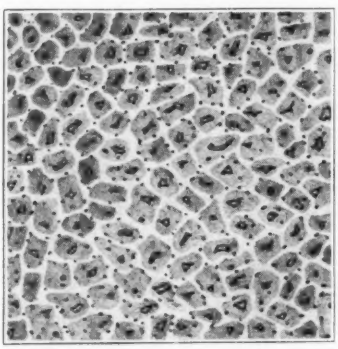


Fig. 7.—Fine grain amalgam produced by heavy grinding. Chemical reactions in setting processes are facilitated by the closer association of the granules when this type of amalgam is condensed, thereby tending to short periods of chemical and dimensional disturbances. These smaller granules go to place with greater ease. (Author's note: This drawing and Figure 5 are rather faulty in that the form and arrangement of the granules, etc, are somewhat more nearly perfect than they appear under magnification.)

Variation 2, wherein the amalgam was allowed to get wet with saliva as the cavity was being filled, was unfavorable in that it flaked and pitted under attrition, apparently owing to the interference

of the saliva with cohesion of the mass. That this is unfavorable in practice is very evident. This type of filling could not be expected to retain a high polish. Variation 3, wherein crystallization was allowed to progress to such a degree that it was necessary to add more mercury and rework the mass before filling, resulted in a very pronounced weakening. This common practice results most unfavorably. With these findings, it was evident that short periods of manipulation, wherein crystallization was interfered with to the least possible extent, gave the best results. Pulverization of the alloy prior to adding mercury was unfavorable

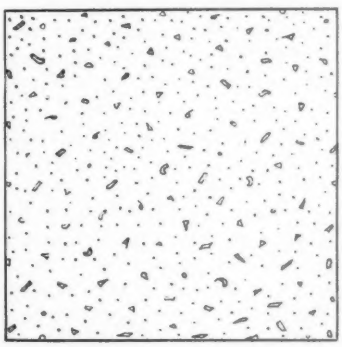


Fig. 8.—Porous amalgam viewed under magnification. A porous amalgam is not so strong, nor will it present such a high degree of luster. Porosity is produced both by underamalgamation and by prolonged amalgamation, together with insufficient condensation and the presence of an insufficient amount of mercury.

in that the normal mixing time appeared to produce overamalgamation. Its resistance to attrition was considerably lowered with the normal mixing time. My conclusions were: The finer the comminution of a given alloy, the more readily it will amalgamate, and thus filings amalgamate more readily than shavings, and the pulverized form more readily than filings. This is in agreement with the findings of certain well known writers on amalgam.

The flexure tests of a given alloy were conducted on the same mixes as the attrition tests, condensing pressure corresponding to heavy hand pressure being constant. A number of tests of different mixes were run, and the average reading in each case was taken. These mixes were tested three hours, twenty-four hours and five days after amalgamation.

The results of the tests for all three periods of setting, with each alloy studied, corresponded with the results of the attrition tests. Every change in procedure

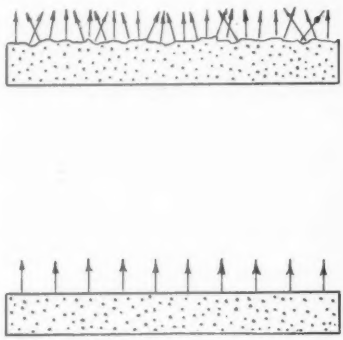


Fig. 9.—Considerations in polishing. Above, irregular surface; below, smooth surface. An irregular, or coarsely cut, surface of amalgam affords a diffused reflection of light rays, thereby presenting a dull appearance; while a smooth, polished surface gives a luster due to the fact that its reflected light rays are not diffused, but are cast in one plane.

that had increased attrition resistance had likewise increased tensile and compression strengths. This finding seems to conflict with certain of the results of the investigations conducted at the Bureau of Standards by Taylor.[1] From this article, it is

1. Taylor, N. O.: Specification of Dental Amalgam Alloys; Report to Scientific Foundation and Research Commission of American Dental Association, J.A.D.A., 17:3 (Jan.) 1930.

assumed, Dr. Taylor concluded that increasing tensile strength depended on decreasing the silver and increasing the tin content of the alloy. From my investigation, it appears that tensile strength can also be increased through manipulation, and without changing the proportions of the constituent metals, condensing pressure being constant. My mode of applying the test was different from that of Dr. Taylor. In the same way, the variations that were unfavorable in the attrition tests were likewise unfavorable in the flexure tests. These results for both attrition and flexure were revealed with

Fig. 10.—Mechanical mortar and pestle, constructed so as to approach duplication in mixing. It is electrically operated and entirely automatic, being mechanically timed. It amalgamates the average alloy in from one to one and one-half minutes, no hand mulling whatsoever being necessary. Thus, the uncertainties of hand manipulation are minimized.

every high silver alloy studied, none excepted. At the same time, the procedures that had produced the best results for attrition and flexure appeared also to produce a controlled expansion in the mass, due to the coordination of the factors in manipulation that produce shrinkage and expansion. Briefly, this coordination is as follows: The heavier grinding advocated tends to cause shrinkage, as does the heavy condensation (heavy hand condensation). These are offset by reducing the mercury, which tends to cause expansion as does the absense of hand mulling. The period of the expanding process seems to be controlled by the close association of the granules and the reduction of mercury content in the mass, both of which are brought about by heavy condensation.

The next consideration was porosity and the factors in producing surface hardness and mass hardness. The study of porosity was best observed under magnification. Although these points of consideration may appear insignificant, a porous mass is not so strong, neither are its attrition values so good, nor does it present a good appearance. Porosity appears to be produced by insufficient amalgamation, together with light condensation; by prolonged amalgamation or manipulation, and by an insufficiency of mercury.

Surface hardness and mass hardness are very important from the point of view of resistance and of service. These qualities increase attrition values, and appear to be produced by the same procedures that are mentioned for producing attrition values. Surface hardness and stability are further increased by building the filling well above the occlusion, thereby bringing excess mercury into this portion and carving it away as soon as condensation is complete. A great deal of the success of the restoration depends on this one procedure.

The next point of consideration was discoloration. For this, the various mixes were condensed into blocks, and these, after polishing, were observed for qualities of texture and color. They were then exposed to oxidation in the open air, and later to the action of certain chemicals. For other tests, the mix that had proved to be good under attrition and flexure was selected, and a number of blocks

made of this particular mix. After receiving the same degree of polishing, each block was dropped into a separate vial of saliva in which was placed a portion of food; such as, the different kinds of bread, steak, potato, cooked vegetable, raw vegetables of different kinds, citrus fruits and mayonnaise. In fact, practically all the common foods were used and some of the drugs that are commonly taken into the mouth, such as tincture of iron chloride, tincture of iodine and dilute hydrochloric acid. Two types of saliva were used: a thick viscid type and a thinner, or more normal, type. These tests were continued from 72 to 108 hours. With these tests, only one block in each type saliva was discolored to an appreciable degree. These were the blocks in the tincture of iron chloride.

The remarkable part of this test was the resistance to discoloration a high quality alloy has, when well amalgamated, well condensed and well polished. Discoloration of amalgam seems to be favored by porosity, insufficient amalgamation, light condensation, high mercury content in the finished filling and the presence of mercury on the surface of the finished filling.

Studies in polishing, with modes and conditions that influence luster, reveal the fact that practically every step in the process of filling the tooth registered its effects in the appearance of the filling: the type alloy used, the degree of amalgamation, the degree of condensation, the ratio of mercury to alloy, etc., all seem to affect the appearance, A smooth surface reflects its rays of light in one plane and will appear brighter; while a stone-cut or irregular surface reflecting light rays in different directions appears dull. Amalgam having a greater degree of surface or Brinell hardness retains a polish longer.

The microscopic studies had to do with the effects produced with light and heavy grinding in the mortar, together with light and heavy condensation, as well as a consideration of the amount of chemical reaction substance produced. Microscopic observations seem to favor short periods of rather heavy grinding as suggested in the accompanying technic.

In trituating, or grinding, certain alloys, it was noted that the mercury attacked the surface of the granules of these alloys very soon after trituration had begun, and before the granules had been broken down to an appreciable extent. This probably was due to the cleanness of the alloy or freedom from oxidation, or probably to a low zinc content; all of which apparently accelerate the union of the mercury with the alloy. This action seemed to result in balling up the mass and retarding the breaking down of the alloy particles. With a little more care, the process is soon effected, but special care must be given if the alloy being used is of this type. It is probably that this alloy has been chemically treated for removal of oxides after cutting. This characteristic, of course, is visible to the naked eye. Two of the alloys were more or less of this type.

It was also noted that both the flexure and the attrition values were reduced when a high percentage of mercury was used, and that the mass was more resistant when amalgamation was produced, with a lower percentage of mercury; condensation being the same. Certain investigators assert that crushing strength is not affected with the higher percentage of mercury; but, from my observation, flexure and attrition are affected.

With a few comments on the electrical disturbances observed, I shall conclude this report, omitting observations and tests on edge strength, etc. With a milliampere meter, measurements were taken of electrical disturbances, created or registered when a freshly mixed amalgam

was placed in one side of a small glass tray containing a 5 per cent solution of sodium bicarbonate or dilute acid solution, in the opposite side of which was placed a small piece of gold. With the positive contact on the gold, at the instant the negative made contact with the amalgam there was registered a peak of from 1,200 to 2,000 microamperes. Generally, the first reading, taken immediately after amalgamation, was not so high as it was from five to fifteen minutes later. From this time on, there was a slow decrease in this disturbance, until a reading of approximately 20 microamperes was reached, which seemed to be rather constant. In some cases, this point was reached in five days; while, in other cases of the same alloy, forty days was required for it to reach the minimum. At first thought, it appears that this disturbance might be purely galvanic; but, when we consider that with different mixes of the same alloy, where depth of contacts and distance of contacts were constant, it was possible to get the different results mentioned, and that the highest readings were produced with fresh amalgam, and that it decreased as the chemical disturbance within the mass decreased, we wonder whether it is purely galvanic. It appears probable that these disturbances, in addition to being galvanic, denote the degree of chemical reaction with accompanying dimensional changes within the mass.

This, with other findings, has not been positively connected with processes of amalgamation, etc., and at present it has no direct bearing on my technic.

TECHNIC

Assuming that proper attention has been given to details of cavity preparation, whereby the peculiar characteristics of amalgam are best accommodated and that an alloy of high quality has been selected, we proceed with speed and precision from the time the mix is begun until completion of the restoration. There should be no interruption or break in the procedure, the cavity being sterilized and properly lined, the matrix adjusted, instruments selected and all else ready at the time the mix is removed from the mortar. The operator should be definite in procedure, making each move count, and thorough, remembering that the material is very sensitive to variations in handling. He should work with a well trained assistant when possible.

A matrix retainer of the type Ivory 8, with thinnest stainless steel bands (0.002 in. thick) is employed. Stainless steel is preferred because it is tougher and more resistant. Bands are cut on an arc so that the diameter of the circle which they form will be smaller at the gingiva. This flared band aids materially in producing proper contacts. A straight ribbon shape band should never be used. Tooth picks may be used as wedges. (Round picks are tough and most suitable.)

Definite proportions by weight of alloy and mercury are used, speed and technic being adjusted to use as low a percentage of mercury as will produce sufficient plasticity, having, of course, a slight excess, which is to be expressed as condensation proceeds. At no time should there be a very soft mass. The strength of a filling made from a highly plastic mix under condensing pressures that are used in the mouth is not so great as when it is made from a less plastic mix, wherein the mode of amalgamation, etc., herein described is carried out. The working time or working plasticity is shorter with a less plastic mass. For this reason, advantage must be taken of all operating time. At first, difficulty in increasing the operating speed may be encountered, but the quality of the filling produced from a less plastic mix justifies the ef-

fort that may be required to increase speed in operation. The lowest percentage of mercury suggested by the manufacturer should always be used, if two ratios are given. Slightly further reduction from this, when there is proper speed in operation and the alloy being used will permit, produces a still more resistant mass. Mixing is done with a glass mortar and pestle, or a mechanical amalgamator, if the proper type is selected. For hand mixing, if a low percentage of mercury is used, a 2-inch glass mortar is recommended. A smaller mortar is not so good except when a higher percentage of mercury is used. The pestle is grasped firmly and grinding is done at from 220 to 240 strokes per minute under a pressure of from 4 to 6 pounds. (To familiarize oneself with this pressure, the mortar is placed on a pair of scales and the necessary strength is determined. A little practice will suffice.) A smooth mass is desired and can be produced with this pressure and speed in from one and one-quarter to one and one-half minutes. Some alloys require slightly heavier grinding. Care must always be used to see that the entire mass is being uniformly ground and that some of the mix is not pushed aside so that it does not receive the same amount of grinding. The fairly heavy grinding pressure brings about a finer subdivision of the alloy, with the result that amalgamation is produced more quickly, and these finely ground alloy particles of the amalgam will assume a close or compact relationship under the condensing thrusts. The mix should be homogeneous. The process is completed in the mortar, so that no hand mulling is required. There should be no mulling either before beginning condensation or during condensation, as is sometimes done in order to keep the mass "alive." It will be noted that where the mixing is carried beyond a certain point, the mass becomes more pasty. This is overmixing and ordinary condensing pressure will not eliminate the mercury.

Condensation begins immediately after completion of the mix and is to be done under heavy pressure. Special and adequate instruments for amalgam, as for other materials, are absolute essentials. An amalgam carrier is used. The assistant fills this and has it ready so that no time is lost in placing each portion in the tooth. The first portion is placed in the cavity just as it comes from the mortar, no mercury being expressed. This is adapted thoroughly to the cavity, condensation, which is rapid but heavy and uniform, bringing excess mercury to the surface. The next portion is added and condensed in like manner, being forced in every direction. If too much mercury is brought to the surface, it should be removed, but a slight amount should be present as each successive portion is added. At the proper time, near completion of the filling, as experience will indicate, all excess mercury is expressed by twisting in a chamois. As the occlusion is reached, the operator condenses heavily toward the margins, thus opening a v-shaped groove. In this is placed a portion of the drier amalgam, which is heavily condensed to place; the mass thus being wedged more firmly against the tooth walls. The filling is built well above the occlusion. Condensation will bring the excess mercury into this portion, which is grossly carved away as soon as condensation is complete, and before the matrix is removed. This early carving will remove the mercury before it has time to diffuse back into the filling. Two, or at most two and one-half minutes, should be used in condensing a filling, since prolonged disturbance of the mass interferes with the setting process and results in weakening. In compound cavi-

ties, the interproximal portion is condensed thoroughly, up to the step, before much effort is made at condensing the occlusal portion. This guards against the interproximal section giving down under the condensing thrusts, as the occlusal section or portion is joined. Should this give, as the occlusal section is joined, a fracture at the angle will be revealed later. Let these points be a guide in condensation: sufficient plasticity, not excessive; perfect adaptation; heavy uniform condensing pressure; removal of as much mercury as possible during condensation; all these things within the shortest period of time, that setting may be disturbed as little as possible.

The matrix is removed and the filling trimmed to smooth margins at this time. The removal of the matrix should always be done with care. It is generally best accomplished by slipping the entire band lingually, then tilting to a pronounced angle and removing one end at a time on a horizontal plane, keeping the band at the angle. It should never be drawn toward the occlusion, nor should the ends which have been crimped be pulled through the interproximal space, as this is liable to break the edge or mar the contacts. With due consideration of these points mentioned, it might be said that the band should be removed in the direction of least resistance. Use of the stiffer mix, together with the heavy condensation, facilitates the removal of the band with much less danger than when a highly plastic mass with light condensation has been used. The carving of the occlusion is completed at this stage. The sulci or grooves are not to be accentuated. There is no advantage to deep grooves, and besides they discolor markedly. Heavy burnishing is to be avoided at this time.

Polishing is done preferably from five to ten days after filling. If several fillings are to be inserted, time is saved by deferring polishing until all the fillings are placed. First, a small mounted stone is used, to bring about flush margins. In doing this, it will be noted that, at times, a very small amount of the tooth is cut away as well as the amalgam. No harm is done by this. Next, the grooves are followed with a polishing bur of suitable shape and size. Now polishing is done with three-eighths or one-half inch regular grit sandpaper disks, followed by the finest grit, then by the finest crocus. It will be found that three-eighths inch disks are more effective in polishing the sulci. The assistant dries the tooth with either a swab of cotton or a blast of air before using disks. Dry disks, aside from lasting longer, are much more effective in polishing. Dry crocus disks of finest grit give a good luster, but by the use of dry prepared chalk or tin oxide, 1 part, and prepared chalk, 2 parts, on a felt wheel, a higher luster can be produced. Frictional heat is always to be avoided in polishing, as this brings mercury to the surface, early discoloration resulting. It also weakens the filling. The interproximal surface seldom requires extensive polishing if a perfectly smooth matrix band has been properly adapted. It is much easier and quicker to prevent overhangs and poor margins by properly adjusting the matrix band than it is to try to carve these away when once they have been formed. For polishing the interproximal, a narrow linen finishing strip of finest grit is generally all that is needed. Using prepared chalk on the strip will give a better luster. Burnishing with a straight explorer or very small instrument is often effective. This can be safely done at this time as the amalgam is thoroughly set. Rather heavy burnishing of the entire surface of the filling at this time tends to close the microscopic pores and bring the reflecting facets into one plane, thereby improving the luster.

Careful study of the foregoing instructions, which at first may seem rather drawn out, will reveal the fact that the entire procedure is simple and concise. With this simple technic, if proper care has been given to cavity preparation, lining, etc., and instruments have been carefully selected for each stage of the operation, an amalgam restoration of genuine worth and beauty can be produced.

As before stated, this technic was in process of development over a period of years. The various steps were arrived at through careful consideration of the work done at the National Bureau of Standards and by individual workers throughout the country, together with considerable clinical observation and a rather drawn-out personal investigation of high silver alloys with a comparative study of their behavior under different modes of manipulation, some of the recently improved or changed alloys being included in the study. Among other things, this investigation revealed that, when this technic is followed, the flexure or combination tensile and compression strengths, together with the attrition values, which are points of great concern to both the patient and the dentist, are markedly increased with every alloy studied, none excepted, excessive expansion being held at a minimum.

ESTHETICS AND OPTICAL ILLUSIONS IN DENTISTRY*

By E. L. PILKINGTON, D.D.S., Detroit, Mich.

WEBSTER defines esthetics as the science of the beautiful in nature and art. In dentistry, esthetics could be defined as the science of copying or harmonizing our work with nature and rendering inconspicuous our art.

Each day, we, as dentists, see anterior teeth in bridges, crowns and full and partial dentures in which there are errors in size, contour and color, and in which, if properly made, no additional time or expense would have been incurred by the operator.

Some of these mistakes may be traced to lack of ability or proper training. Others may be due to poor eyesight or color-blindness; while still others may be due to unfamiliarity with the measures used to produce optical illusions. This presentation will deal with these errors, the reasons for them and the corrective measures that can be employed to eliminate them. All types of work will be considered: simple fillings, inlays, crowns, single and multiple tooth bridges and, finally, full and partial dentures.

SYNTHETIC PORCELAIN FILLINGS

Let us first consider the much used and ever maligned synthetic porcelain filling material. It has been used more than any other anterior filling material, is used and will be used, despite the fact that its greatest fault is evidenced most noticeably in the very place it was intended for; that is, the anterior teeth. It would seem that after more than twenty

*Read before the Section on Operative Dentistry at the Seventy-First Annual Midwinter Clinic of the Chicago Dental Society, Feb. 19, 1935.

years, the manufacturers would have had time to bring out a material entirely resistant to the gradual dissolution so characteristic of the filling of today. In the absence of such a material, various methods of mixing, insertion and finishing have been devised, in an attempt to minimize the wasting process and prolong the life of the filling.

We are now condemning overspatulation of the filling material, and advocating the incorporation of the proper amount of powder, with a minimum of mixing. A mere stirring together of

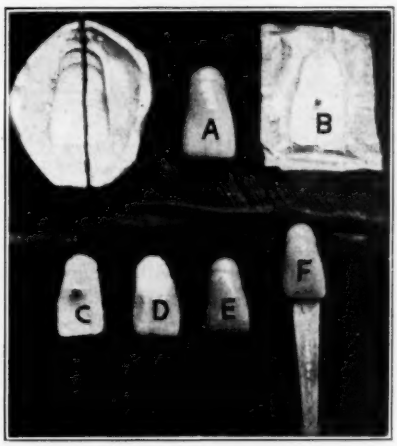


Fig. 1.—*A*, stock tooth from which Mellotte's metal mold was made. *B*, tissue paper adapted to mold, porcelain added and pin inserted. *C-E*, porcelain biscuited, shaped and glazed. *F*, facing fixed to holder.

powder and liquid, letting the liquid absorb the powder until the spatula can be raised free from the mass with a clean break, is said to be the proper technic. Overincorporation of powder with too much spatulation may produce a jelly-like mixture, with consequent opacity, weak edge strength and loss of color.

Stainless steel or agate instruments should be used to insert the filling, and, wherever possible, it should be confined under pressure with a celluloid strip or other suitable means until the initial set has developed.

Now comes the most important and most difficult task of keeping the filling dry until final setting takes place. There have been many materials used to coat these fillings. Most of them are guttapercha or various gums dissolved in solvents such as chloroform and ether. After being painted on the tooth, the solvent evaporates and the film shrinks, with consequent pulling away from the

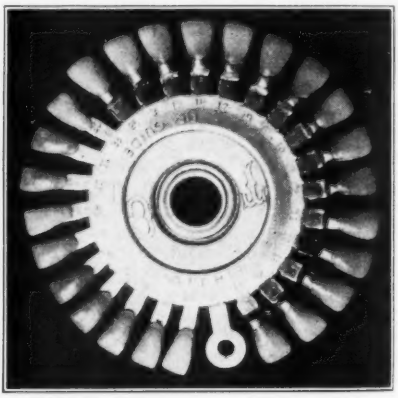


Fig. 2.—Shade guide with ten or more basic colors and jacket crowns or facings, using various blends of basic colors.

tooth, leaving little protection against moisture.

The paradox of synthetic porcelain is that it must be kept dry while setting and must be kept wet after setting. I frequently explain the solubility of these fillings to patients by comparing this wasting away process with that occurring to piles or log supports under docks and bridges. Here, we find all of the wet and dry elements found in the anterior part of the mouth. The submerged portion

of the log lasts indefinitely, but all of us have seen the rotting and erosion that takes place at the water line owing to the alternate wet and dry action from the rise and fall of the water level. This comparison is very effective because most patients have had some silicate fillings in the posterior teeth which always remained wet and stayed in place, while the anterior teeth did not. It explains to them why people with long upper lips and short upper teeth have little trouble with silicate fillings and also why mouth breathers and people who show their teeth conspicuously apparently cannot get fillings that will be satisfactory after six months.

We cannot protect teeth from getting wet and dry after the fillings are set, but we should be able to, and can, protect

Fig. 3.—Side view of teeth ground to fit receded ridge.

Fig. 4.—Front view of teeth shown in Figure 3. These teeth have the same length and width.

them from moisture while they are setting.

PARAFFIN AS A PROTECTIVE COAT

The protecting coat should be colorless, to keep woman patients from wanting to remove it; it should melt at a low temperature; it should flow like water when melted; it should not shrink away from the tooth while chilling; it should chill immediately, and it should stick to the tooth, giving a positive seal, with reasonable care, for twenty-four hours. We have such a material in common paraffin wax, sold in any grocery store for 15 cents a pound. This wax will flow with equal ease into interproximal spaces or under the free margin of the gum.

TRICHLORACETIC ACID AS A GUM STYPTIC

Many of you have observed in cervical and interproximal silicate fillings the almost inevitable trench or ditch that appears after the first year between the cervical wall of the cavity and the bulk of the filling. The rest of the filling may be as good as new, but that crack is nearly always present, the reason being that the floor and cervical wall of the cavity were not completely dry when the filling was inserted, and part of the filling was affected by the moisture present. Seepage of moisture from the gums is hard to control even with the use of the rubber dam, and this is very objectionable to patients.

The use of trichloracetic acid, diluted until there is just the faintest blanching of the gum tissue on application, will effectively control seepage of moisture from this source.

It is also well to pack the filling into the cavity at the cervical margin, patting it to place, rather than risk pulling the filling away from the wall by stroking, and also risking a flow of moisture or blood by too much disturbance of the gum tissue. In all cervical cavities, regardless of the type of filling, it is imperative to pack the gum tissue back with guttapercha and expose the gingival edge of the cavity before attempting a filling.

KRYPTEX

With the advent of "kryptex" as a

filling and cementing medium, we have a quick setting material which has practically supplanted cements in porcelain inlay work and, to some extent, in jacket crown work.

As a filling material, kryptex is rather opaque, and particularly so if any great amount of spatulation is used in mixing powder and liquid. The color range is inadequate for use in the anterior part of the mouth and is hopelessly at variance with that of the color guide submitted by the makers. The material is apparently stronger than synthetic porcelain and is tolerated by the gums much better than any silicate filling, being the choice

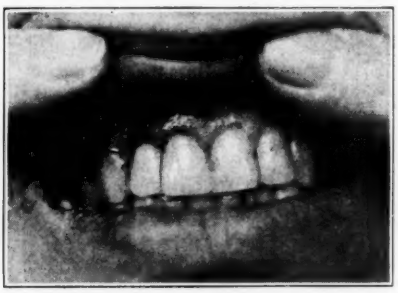


Fig. 5.—Practical case illustrating principles used in Figures 3-4. The two central incisors are facings.

in cervical fillings where the color can be matched.

When this material is used as a cementing medium in porcelain crowns and inlays, it is as important to protect the kryptex cemented margins with paraffin as it is in synthetic porcelain fillings. It is also important to protect the stump of a jacket preparation by a good varnish to keep the kryptex from touching the tooth when the crown is cemented, for it has caused severe pulpitis, and also the death of the pulp.

Germicidal Kryptex.—I want to caution you regarding germicidal kryptex. This material should be used only where subsequent discoloration of the tooth is not objectionable. The 0.2 per cent mercurammonium chloride (NH_2HgCl) used as a germicide in this preparation will stain teeth, the stain varying slightly with different powders, from a bright blue to a dull gray or black. This material should never be used as either a cementing or a filling medium in the anterior teeth.

A strong point in favor of kryptex, either plain or germicidal, is the speed with which it sets. This enables the operator to keep the patient under his immediate observation until it is safely set.

Since the trend of this paper is to point out our errors, their reasons and possible

Fig. 6.—Illusion of narrowness accomplished by grinding.

correction, we cannot dwell long on those types of restorations the silicate fillings were designed to supplant. It is true that in 90 per cent of cases in anterior teeth, silicates have succeeded in supplanting other fillings, but it is also true that in no case have they succeeded in attaining the high standards established by gold or fused porcelain.

D. M. Cattell[1] rates the various fillings according to their value to the patient as follows: gold foil, 100; gold inlay, 70; porcelain inlay, 40; silicate filling, 20; cement filling, 10. This certainly illustrates the need for improvement of silicate filling materials, both in

1. Cattell, D. M.: Pac. D. Gaz.

their manufacture and in their manipulation.

PORCELAIN INLAYS

Errors in porcelain inlays are fewer, owing to the excellent technics that have been developed. Close attention to recognized form of cavity preparation will eliminate to a large extent breakage and loosening of inlays.

In interproximal and proximal incisal cavities, cutting the labial wall of the cavity perpendicular to the labial surface of the tooth will place the cement line of the finished inlay exactly edgewise and render it inconspicuous.

Perhaps the most common error in cervical inlays is the alteration of the color, due to cementation. We may find that the uncemented inlay in the cavity

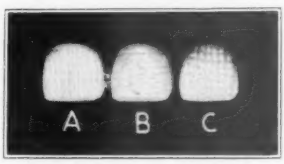


Fig. 7.—Illusions of, *A*, height; *B*, flatness and breadth, and, *C*, bulging, obtained by grinding grooves in surface.

is invisible, but the moment cement is added, the color is altered. A colorless cement would be perfect, but all of our cements are colored and more or less opaque. Experienced ceramists solve this problem by choosing a cement one shade darker than the true gingival color of the tooth to offset this loss of color.

PORCELAIN JACKET CROWNS

Errors in porcelain jacket crowns may be divided into seven classes:

1. *Tooth Anatomy.*—Close attention to the adjacent teeth will enable the operator to grind the crown to suitable anatomic form. If adjacent teeth are lacking, a study of extracted square, tapering and ovoid teeth is necessary to observe the gross outline of the teeth and the surface markings, whether labial surfaces are flat or rounded and whether the grooves are shallow or deep.

2. *Surface Texture.*—Owing to abrasion and tooth brushing, many teeth have a high polish. Other teeth have a dull bonelike texture, due to surface markings; while still others are polished on the incisal half and dull on the gingival half.

A high glaze will sometimes match a high polish, but usually additional polishing with tin oxide is necessary to copy

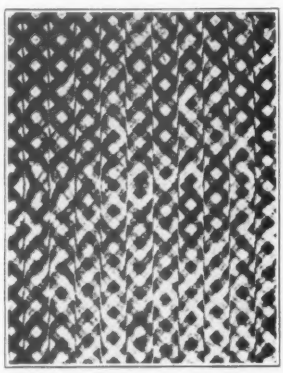


Fig. 8.—"Twisted cord" illusion (these are straight cords), a principle which can be used in grinding anterior teeth.

the exact texture of such a tooth. A high biscuit or mat glaze will suffice for the dull, deeply marked tooth, with perhaps some slight disking and polishing, while the same mat glaze, with more disking and polishing, will fit the half-dull, half-polished tooth.

3. *Gingival Contour.*—Many jackets as well as Davis crowns do not reestablish the labial gingival contour of the natural tooth. It is imperative to provide sufficient bulge at this point to extend

out over the gum tissue and push the food out and away from the free margin of the gums during mastication. Failure to do this is death to gum tissue, always resulting in soreness and recession of the gums, with subsequent root exposure and an unsightly showing of cement lines. It is better to overbuild the crown at this point than underbuild.

4. *Color.*—The author places color second to form in importance in jacket crown work, for reasons to be given later.

Securing form is a mechanical matter, mastered in a short time, but color calls for endless study, particularly where

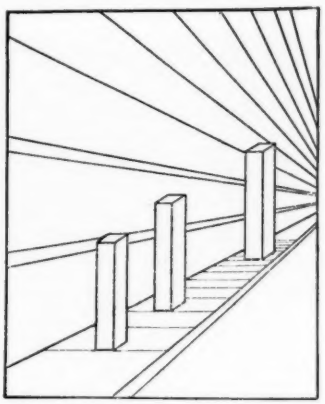


Fig. 9.—Striking illusion of perspective. The last post is the same length as the first. This illusion is paralleled in the posterior teeth in the mouth.

colors are overlaid and translucent. Color values are varied with different batches of porcelain and by the degree of condensation of the porcelain, and can be varied by the heat treatment of the built jacket. Underfused porcelain has a much duller hue and is more opaque, while overfused porcelain becomes lighter and tends to become transparent. All shades, from dark to light, may be obtained by increasing the heat above the maximum heat of the porcelain, owing to the fact that porcelain and porcelain shade guides as supplied by the manufacturers are rarely accurate, even the guides themselves not coinciding.

I have advocated in former articles the purchase of several ounces of cement of the colors most used by the ceramist as the best means of eliminating the difference in colors in various batches of porcelain. Facings to represent these colors can be made, the operator using a split Mellotte's metal mold. Combinations of colors can be used and facings made with cervical, middle third and enamel colors, in their respective places. In fact, a

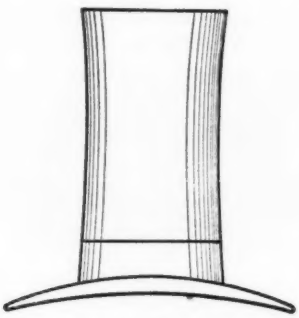


Fig. 10.—Illusion in which vertical dimension is equal to horizontal one, the former appearing greater. This illusion is applicable to teeth.

whole shade guide can be made, the only limit being the ingenuity of the operator.

5. *Multiple Jackets.*—In cases of multiple jackets in different sized teeth, it is very difficult to get the balance between the amount of dentin color and enamel color in all teeth just alike. If too much yellow is used, the tooth will be dark; if too much enamel is used, the tooth will be light. Harmonizing the amount of dentin color in all teeth before any enamel is placed will effectively take care of this difficulty. It may be expedient in

difficult cases where color and harmony in size are important to cut away the lingual portion of anterior plate teeth and use the shells left for the labial portion of the jackets. The new "trubyte" teeth, with their fine color and type assortment, will be found entirely adequate in most cases. These are also sold in sets of six with the lingual portion already hollowed out for this purpose.

6. *Typal Forms.*—When nature combines teeth and faces of like proportion and outline, the effect is harmonious, but when ovoid teeth are found in tapering faces and tapering teeth found in square faces, the effect is anything but pleasing.

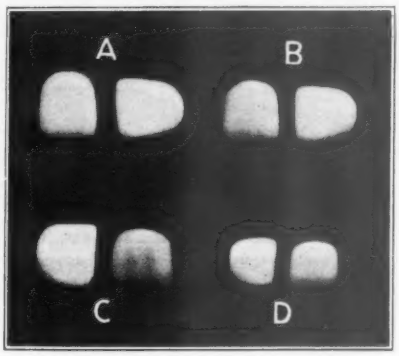


Fig. 11.—*A-B,* teeth in which height is greater than width. *C,* teeth the width of which is greater than the height. *D,* teeth the width and height of which are equal. (Rotate picture and compare with Figure 10.)

It is necessary to know types, modifications of types and correct tooth form for each type to give the proper tooth form to jackets in multiple crown cases when both upper central incisors are involved.

The manufacturers have supplied us with a mechanical device known as the Waverin guide which points out the proper size and type tooth for any given case. The use of mechanical aids such as this or other patented guides to facilitate the selection of teeth may be most successful in the hands of men who, by reason of their large experience, are able to dispense with such aids, but they certainly are the best means available for the inexperienced operator for the proper selection of teeth. These, together with the manufacturers' mold books, having photographs of various faces and teeth that harmonize with these faces, should effectively solve any question of proper shape in any multiple jacket case.

7. *Cementation.*—As it is possible to alter considerably the color of the cervical half of a jacket crown by the use of the wrong shade of cement, it is advisable to make a test mix of cement powder and water to see what effect the cement color has on the shade of the jacket before final cementation.

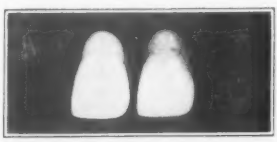


Fig. 12.—Illusion respecting size. The darker tooth is actually wider than the lighter tooth.

BRIDGE FACINGS

We have thus far studied the complete set of anterior teeth with each tooth standing on its own feet, so to speak, with no teeth missing. Let us now consider some of the common errors, with their causes and cures, in restorations wherein one or more teeth are missing.

Recent Extractions.—The greatest problem in replacing newly extracted teeth with bridge facings is determination of the amount of gum shrinkage that will take place. As most bridges of a fixed character are considered permanent by the patient, the gold backing must be in proper buccolingual and incisocervical

position to accommodate a new facing, if it becomes necessary.

The problem of esthetics becomes more complex in proportion to the number of teeth lost, because of the increased amount of shrinkage. It is a rarity to find facings in either fixed or removable bridgework that do not stand away from the gum after six months or a year.

Observation of a large number of cases has shown that the eventual shrinkage of the gum tissue will place the crest of the ridge at a point approximating the center of the original root socket. This may vary slightly, sometimes being more in the upper cuspids, but rarely being less

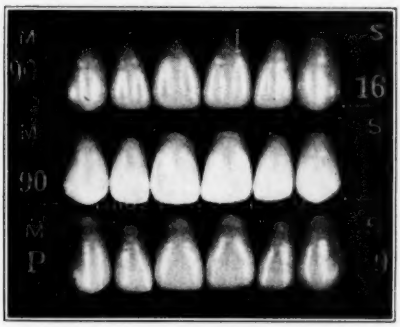


Fig. 13.—Brightness contrast. The teeth at the bottom are larger than those in the center.

in the other teeth. If a study of partial denture models is made and the knowledge gained thereby is applied to positioning facings in recent extraction cases, there should be a minimum of replacements necessary.

Old Extractions.—In normal cases, there can be no reason for ever lapping facings over the labial aspect of the ridge. Besides being very unsightly, it is extremely unsanitary, and no discriminating patient will long tolerate this.

There can be no excuse for not abutting the facing square against the labial aspect of the ridge. Sufficient material should be removed from the model at this point to allow for a slight condensation of the gum tissue, in order to insure natural appearance. If still further absorption results, it is quite probable that this is due to irritation of the ground facing. Few dentists are equipped to reglaze porcelain, but they should be able to and can polish the ground area because every dentist has a lathe, ragwheel and tin oxide.

Cervical Bevel.—In beveling the cervical margin of a facing to secure a pleasing effect, we bring into use the

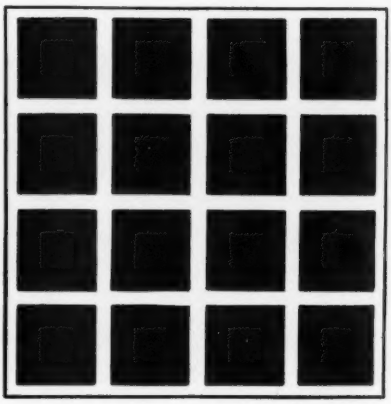


Fig. 14.—Effect of brightness contrast. (Note darkening of intersections of white strips.) (Figures 8, 9, 10 and 14 from Luckiesh.)

principles used to produce optical illusions. The illusion of the proper length of a facing is sometimes difficult to obtain, especially if the replacement is a central or lateral incisor closely approximating a normal central or lateral tooth for comparison.

A square-edged stone held at approximately a 45 degree angle with the long axis of the tooth will bevel the edge and make it appear the same length as its ad-

jacent counterpart, without disturbing that part of the facing in contact with the gum.

In cases of extreme absorption wherein a much longer tooth is required, the gingival outline of the enamel can be ground into the facing in addition to the bevel.

Mesial and Distal Bevel.—A much longer tooth is invariably wider as well, making it imperative to continue the grinding started with the gingival outline and carry it into the interproximal area and also on the labial surface as well as the mesial and distal sides of the facing; stoning them down to a contour compatible with that of the remaining natural teeth.

Oversized Facings.—Another and very practical optical illusion can be created in those cases wherein the space is too narrow for two facings and seemingly too wide for one. A facing of the proper width can be selected and a complete new tooth shaped on the labial aspect of the facing without narrowing the underlying part of the facing. Labial form and incisocervical and mesiodistal dimensions can all be ground in, and the facing finished by polishing or glazing. At times, it may also be expedient to resort to a slight stain on the mesial and distal sides to give the illusion of shadow in the interproximal spaces.

Variations in this method of shaping teeth are being employed by one manufacturer in the molding of new bridge faces, which will shortly be available on the market.

Straightening Out of Line Facings.—Frequently, the space left by the extraction of an upper lateral incisor has a decided distal slant. This is especially noticeable in tapering types. If a replacement tooth is put in this spot, it appears to have a decided distal slant. The space is usually too confined to permit the cervical of the facing to be twisted distally, and even if there were space, the twisting would leave an unsightly interproximal space on the mesial side. The incisal edge of the natural lateral incisor on the other side will distinctly slant mesially, but an examination will disclose that the same difficulty would be had in replacing this tooth. Obviously, then, Nature has a way of creating an optical illusion of her own, and an examination of the extracted tooth will confirm this.

A tooth having a porcelain root is indicated in this case, and the same technic of grinding a new labial surface as mentioned before, bringing the long axis of the new face in line with that of the adjacent teeth. Teeth with porcelain roots have sufficient body or porcelain at the root end to allow for the grinding necessary to slant the cervical edge of the new face distally and still fill the interproximal space mesially.

Multiple Facings in Bridges and Partial Dentures.—In multitooth cases, the mode of procedure is the same as for single teeth or facings, the increase in number of teeth only adding to the possibilities of securing needed or esthetic changes in type or alinement. In other words, the possibilities of the finished case are only limited by the operator's skill and experience in rotating teeth and twisting teeth, and in esthetic misalinement.

Campbell[2] states that because the teeth as manufactured are necessarily uniform in appearance and not adapted to the individual requirements of harmony, the characteristic markings of the teeth due to age must be supplied by the operator. The teeth as manufactured are designed for patients of younger years than those who ordinarily require this type of replacement.

2. Campbell, D. D.: Full Denture Prosthesis, St. Louis: C. V. Mosby Co., 1924.

PERCEPTION AND ILLUSION

Thus far, we have dealt with color and form in a general sense as related to problems of selecting and harmonizing teeth according to type. Let us now enter more specifically into the field of visual reactions as related to these problems, and delve into the reasons that we think we see what we actually do not see in many cases.

When a patient comes into our office and we examine his teeth clinically, precisely what do we see, and in what chronologic order does our visual apparatus perceive color, size, harmony and surface texture of these teeth? In other words, what is the first thing we see when we look at a tooth?

Luckiesh[3] finds that the most elementary response of our visual sense is to light. Parsons[4] finds that the discrimination of minimum displacement for the appreciation of movement ranks next to light, and is of the same order of magnitude as that for contour. Luckiesh agrees with him and says the perception of outline form and surface content perhaps ranks next in simplicity. The perception of these is so direct and so certain that it may be considered immediate. The perception of solid or surface form is far more complex than the perception of outline form, and therefore more liable to error. It is judged partially by binocular vision or perspective and partly by the distribution of light and shade. Colors may help to mold form and even to give depth to flat surfaces.

We can conclude from this that the order of visual perceptions are as follows: light, movement, outline form, surface form and, finally, color. It follows, therefore, that errors in outline form or gross anatomic form of a tooth are the first thing the eye perceives, with surface form second and color third.

We distinguish objects by contrasts in brightness and in color, and we recognize objects by these contrasts, which mold their forms. Much work has been done in past years in studying the minimum perceptible contrast, and it has been found to vary with hue, with the magnitude of brightness and with the size of the image; that is, with the distance of an object of given size.

COLOR FATIGUE

When an image of a bright object exists on the retina for a time, there results a partial exhaustion or fatigue of the retinal processes, with the result that there is an after image. This dies out, but when the eye is again directed toward the illuminated surfaces, the part of the retina which has been fatigued does not respond as fully as the fresher areas, with the result that the fatigued area contributes a darker area in the visual field. This is known as an after image. An after image of a colored object may often appear of a color complimentary to the color of the object. It has been found that the retina can interpret color correctly only a few seconds at a time before fatigue destroys the sense of color values. This explains why it is impossible to shade a tooth correctly after prolonged matching with a shade guide. First impressions are always best.

There are almost numberless phenomena involving color, many of which are illusions, or seemingly so. It will be obvious that many are errors of sense, some are errors of judgment and others are errors due to defects of the optical system of the eye.

EFFECT OF LIGHT ON COLOR

In general, colors the dominant hues

3. Luckiesh, M.: Visual Illusions, New York: D. Van Ostrand Co., 1922.

4. Parsons, J. H.: Theory of Perception, London: Cambridge University Press, 1927.

of which are of the shorter wave lengths (violet, blue, blue-green, green) are retiring, and those whose dominant wave lengths are longer (yellow, orange, red) are advancing.

The relative sensibility of the retina varies for different colors with a change in brightness, or it may be better to say that the relative sensations for various colors alter as the brightness values are reduced to a low intensity. This, called the Purkinje effect, may in general be described as an increasing sensibility of the retina for light of short wave-lengths (violet, blue, green) as brightness decreases, or a corresponding decreasing sensibility for light of longer wave-lengths (yellow, orange, red).

We may conclude from this that teeth containing blue, blue-green or green are overly conspicuous in dim and artificial light, while teeth containing pink, orange or yellow are less conspicuous and therefore the choice for use in full or partial denture work.

EFFECT OF LIGHT ON FORM

As the intensity of illumination increases, all colors appear to become less saturated, and surface markings, surface contour and polish become the dominant factors in the illusion regarding the size of the tooth. A smooth tooth appears larger than a rough tooth, a polished tooth appears larger than a dull tooth and a light tooth appears larger than a darker tooth of the same size at the same distance. Under artificial light from lateral illumination, a bulging tooth placed beside a flat tooth of the same shade will look larger and brighter, and the illusion will increase with the increase of the light source.

CONCLUSION

The dentist deals in form and contour, and he deals in translucent colors, one laid over the other against the dark background of the oral cavity. His colors must stand the test of bright light, dim light, daylight and artificial light. The artist deals in flat colors on a solid background, and still his pictures painted in the daylight do not have the same appearance under ordinary artificial light. The dentist resorts to illusion and camouflage, a vast field of activity in scientifically concealing and deceiving. The artist has aided in this development, but the definite and working basis of all branches of illusion and camouflage are the laws and facts of light, color and vision as the scientist knows them. Science consists of knowing, art consists of doing. If the dentist is familiar with the facts of light, color and lighting and vision, he will possess knowledge that can aid him in overcoming the obstacles that are ever present in his profession.

MAPHARSEN, A NEW THERAPEUTIC AGENT FOR VINCENT'S INFECTION*

By P. A. DUEHR, M.D.; L. L. WEISSMILLER, M.D.; R. L. McINTOSH, M.D.; G. A. COOPER, M.A., and A. L. TATUM, M.D., Madison, Wis.

IT is well known that the treatment of certain cases of Vincent's infection, or "trench mouth," is a most tedious and protracted undertaking and one in which a host of therapeutic agents have been employed. Because of the rather prompt response frequently obtained with the topical application of arsphenamine, neoarsphenamine, Fowler's solution, etc.,[1] it was decided to investigate the possibilities of mapharsen. Since there are quite a number of substances belonging to the generic group of arsenoxides, we have designated that oxide related to arsphenamine by the term mapharsen. This word is made from the chemical name meta-amino para-hydroxy phenyl arsenoxide. This is an arsenical preparation (meta-amino para-hydroxy phenyl arsine oxide) which was recently studied in experimental syphilis by Tatum and Cooper,[2] and thereupon employed by Foerster and his colleagues in the treatment of human syphilis. It is an agent that presumably acts immediately on certain susceptible organisms without having first to be changed into an active form, as is considered to be the case with the arsphenamines. It was thus argued that this drug might well excel the arsphenamines in efficiency in the treatment of Vincent's infection.

The cases of typical Vincent's infection, as they appeared at the clinic, presented symptoms varying from slight bleeding and redness with no pain or tenderness to profuse bleeding, with softness and sponginess of the gums and considerable ulceration. The presumptive diagnosis was made from the history, which practically always included bleeding of the gums and pain following brushing of the teeth. The clinical diagnosis was based on bleeding, tenderness, swelling and redness of the gums, and the finding of fusiform bacilli in the presence of spirochetes in the smear. Buccal and tonsillar involvements were identified by the appearance, together with examination of smears obtained from these lesions.

Individual records were kept, noting bleeding, tenderness, the presence of a membrane, ulceration, recession of the gums, swelling and the color of the gums, and, in instances of extragingival lesions, appropriate descriptions. The treatment and microscopic control from a study of smears were also recorded.

*From the Wisconsin General Hospital and the Department of Pharmacology of the University of Wisconsin.

1. Smith, David T.: Oral Spirochetes and Related Organisms in Fusospirochetal Diseases, Baltimore: Williams and Wilkins, 1932, p. 243.

2. Tatum, A. L., and Cooper, G. A.: Meta-Amino Para-Hydroxy Phenyl Arsine Oxide as an Antisyphilitic Agent, Science, 75:541 (May) 1932; An Experimental Study of Mapharsen (Meta-Amino Para-Hydroxy Phenyl Arsine Oxide) as an Antisyphilitic Agent, J. Pharmacol. & Exper. Therap., 50: 198 (Feb.) 1934.

METHOD OF APPLICATION

Since the technic of treatment is of paramount importance in the therapy of this disease, we feel justified in giving rather full details.

Two types of applicators were used. One was a thin nickeloid wire set in a removable handle and which could be bent into any desired shape. The other was an ordinary hardwood applicator that had been cut off obliquely, a long flexible point resulting. A very small amount of cotton was wound on the end of each of these instruments. Enough cotton was used to cover the point of the applicator and was slightly moistened so as to pick up the dry powder.

In most cases in which the saliva seemed particularly mucoid, the gums were wiped dry, then moistened with water. The drug was then applied by means of an applicator to the gums, under gum margins, between and around all of the teeth and in the gingival pockets. One winding of cotton was usually found sufficient for treating one entire jaw unless there was considerable bleeding, in which case the cotton was replaced at frequent intervals. Treatment was not followed by use of a mouth wash or rinsing unless the patient complained of burning or aching. In the latter case, the symptoms were usually promptly relieved by rinsing the mouth with either warm or cold water.

All severe cases were treated daily, mild or subsiding cases being treated every other day or three times weekly. The amount of drug used for a single treatment was usually from 40 to 60 mg.

For buccal and tonsillar lesions, the drug was either applied as in the treatment of gingival lesions or, if this was found impractical for any reason, applied by means of pledgets of cotton soaked with a 1 to 10 per cent solution of the drug.

The following three brief case reports of gingival infection will serve to illustrate: (1) an easily cured case, (2) a resistant case and (3) an average case.

REPORT OF CASES

CASE 1.—In February, 1932, the patient, a man, developed Vincent's infection and was treated with various drugs, which, for a time, improved the condition but did not completely heal the gums. In October, 1932, shortly after discontinuing treatment, the patient was seen in this clinic. Examination at this time revealed profuse bleeding, moderate tenderness and considerable swelling. A smear taken from the gums showed very many fusiform bacilli. The day after the first treatment by the use of mapharsen, the gums appeared normal and there was no bleeding, tenderness, redness or swelling. The subjective symptoms were entirely gone, and the smear showed only a few fusiform bacilli. After the second treatment, the smear was negative. The patient received four additional treatments. He was seen twice a month for several months after recovery and the gums remained normal.

CASE 2.—For about three months, the patient had noticed bleeding when brushing the teeth. At the time he came in for treatment, he had no bleeding, but did have slight tenderness and slight redness and swelling of the gums. Smear examination revealed very many fusiform bacilli. Tenderness disappeared after one treatment, swelling after five treatments and redness after nine, but smears continued positive until after thirteen treatments (twenty-one days). The patient had extensive concretions on the teeth and would not take advice to have them scaled. This case, and several similar ones, indicate that concretions impede recovery.

CASE 3.—The patient reported bleeding and tenderness of the gums continuing for six months. A smear showed many Vincent organisms. The bleeding was profuse and tenderness was marked. There was a moderate amount of ulceration and much swelling and redness. Smears became negative and the ulcerations were healed after three

treatments. Bleeding ceased after four treatments and the swelling, redness and tenderness disappeared after six treatments. The patient was under observation for the succeeding ten days, and the gums remained normal.

When treatment caused bleeding, a patient usually complained of a smarting sensation in the gums. This was almost invariably relieved by rinsing the mouth with water. A few patients complained of pain in all the teeth immediately after the first treatment. When there was no bleeding, there was no smarting nor pain connected with the treatment.

In cases of gingival recession, some diminution in retraction was noted, but when the recession was marked, the gums were not restored to their normal level within the time of our observations. It was observed that dental caries and neglect of the teeth greatly impeded the recovery. The presence of crowns and bridgework interfered in some instances with the proper application of mapharsen. The drug itself produced no objective manifestations of any direct tissue injury.

In a study of thirty consecutive cases, the average time required for cure of gingival lesions was nine and four-tenths days. The average number of treatments before the smear was negative was three and three-tenths. Bleeding was stopped in an average of three and one-tenth treatments. An average of three and two-tenths treatments were required before the tenderness disappeared. The average number of treatments required to heal the ulcers was three and one-tenth. The swelling disappeared with an average of four and one-tenth treatments and the redness was gone after an average of four and four-tenths treatments.

Several cases with tonsillar involvements were treated with solutions of mapharsen. The solutions were used because of the tenderness of the ulcerated areas, and the difficulty of application of the powder to the tonsils. The involved area was usually swabbed once a day with 1 per cent solution of the drug, and a gargle of 0.4 per cent was used three times a day. It was found that an alkaline gargle used just before the mapharsen gargle removed the mucous secretions and apparently permitted the mapharsen to reach the deeper structures more effectively. Usually after the first day, the throat was subjectively less sore, and the membrane, if still present, was observed to be receding. In a number of our cases in which the tonsils only were involved, the lesions were healed in from three to six days.

We had occasion to see five cases of infectious mononucleosis associated with Vincent's infection. In four of these cases, the oral lesions were healed in from five to eleven days, followed closely by reversion of the blood picture toward normal. In one case, for some obscure reason, the condition was more refractory, but was cured in fifteen days. In these cases, a solution of mapharsen was applied topically to the oral lesions.

There were two cases in which the whole buccal cavity was more or less involved. On account of the extent of oral infection, these patients were given intravenous injections of mapharsen supplementary to the usual topical applications. The most severe case is summarized as follows: The lips, buccal cavity, tongue, tonsils and gums were so involved that the patient was unable to eat. He had been treated for two weeks previously with hydrogen peroxide, neo-arsphenamine and 4 per cent chromic acid, without relief. He was then treated by the use of mapharsen. In addition to mapharsen mouth washes, this patient was given a first intravenous injection of 30 mg. of mapharsen and, beginning four

days later, three successive intravenous injections of 60 mg. each at four-day intervals. After the first injection, there was a noticeable regression of lesions. In twenty days, the smears were negative and the patient was discharged as cured after twenty-six days.

Several cases with superficial gum lesions only did not respond to from three to eight intravenous injections, but were promptly cured by the local application of the drug. It would seem, therefore, that intravenous injections of mapharsen are of obvious value only when the tissues involved are well vascularized. Gingival lesions or infections did not respond to this type of therapy so well as to local applications, presumably because of the inability of the drug to reach the organisms via the blood stream.

In regard to the extent of use in the Wisconsin General Hospital, we must admit that it is practically impossible to state accurately how many cases of Vincent's infection have been treated by the use of mapharsen during the past three years, for the reason that, after a careful study of about thirty consecutive cases, the method was generally adopted on the various services throughout the hospital. In many instances, Vincent's infection was found in routine examination of patients hospitalized for other reasons. In addition to its use in this hospital, the drug has been submitted for trial to several of the leading dentists in this city. By personal communications, they have informed us that their experiences fully coincide with ours. All in all, the cases treated with mapharsen should certainly run well into the hundreds as based on average morbidity rates for this disease in this region. Our series of cases of infectious mononucleosis is too small to justify any general conclusions as to the efficacy of mapharsen. Our experience with the five cases, we feel, would justify its trial in new cases as they become available.

GENERAL CONCLUSIONS

1. The use, locally, of mapharsen, in aqueous solution or in solid form, caused neither necrosis of, nor other objective damage to, the mucous membranes of the mouth.

2. Vincent's infection, limited to the gums, yields, with remarkable promptness, to treatment with mapharsen in powder form.

3. Although topical application of mapharsen generally proves satisfactory for treatment of extragingival lesions, an occasional case may require intravenous together with local therapy. Intravenous therapy alone is generally unsatisfactory for gingival lesions.

4. Mapharsen yields quicker and more satisfactory results, and with fewer treatments, than any other agent known to us.

THE RESEARCH COMMISSION*

By C. T. MESSNER, D.D.S., Washington, D. C.

THE American Association of Dental Editors is a unique organization with respect to the influence that its members can exert in guidance of the affairs of the profession.

It would be impossible to cover here the history of the Research Commission or outline its various activities since it was first formed at the meeting of the National Dental Association in Kansas City, Mo., in 1913. Neither would it be practical to outline the aims of the commission at the present time or its accomplishments in the past. What is of paramount importance is the policies that are being pursued at the present time and whether progress is being made.

It is only natural, and to be expected, that anything of a practical or spectacular nature is quickly grasped by the public imagination and given front page publicity, while the obscure discoveries, not entirely practical in nature, are delegated to the back pages, where only those who are interested in that particular fact will be apt to see them.

To a great many individuals who have not come in direct contact with original research, and especially is this true of biologic research, the subject is dull and lacking in appeal to the imagination and interest. To those who are not satisfied with our present knowledge and who are interested in finding new paths to tread, there is something intensely exciting and adventurous in following some unbeaten path, to discover new truths. To such men, there is still adventure, romance, danger, thrills and tragedy to be encountered in this old world of ours, as in days of old when men went forth to find new worlds to conquer.

The map of the world was many years in the making, but it is now almost completed. Never again will a Cortez or a Pizarro return from new lands to fire our imaginations with tales of conquest, although we love the romance of it still, and until the end of time, men will thrill to read of the treasure ships returning as described in Masefield's poems.

For those professional men who have the proper background of training and inclination, there are still many worlds to discover. In the fields of dentistry and medicine, there are still vast wildernesses untrod by human foot, secret places that no eyes have seen, buried treasure yet unfound. Just around the corner, around many corners, are wonderful new things; for the world of medicine is new; it is not half explored; its wealth and possibilities are yet unrealized. The search for health and the exploration to determine the cause of disease have been in progress since the beginning of time, yet comparatively little has been accomplished. The care of the sick through all the ages has been the index of the progress of human civilization. Centuries have passed since the time of the ancient temples of healing, to bring us to the modern hospital of today.

If the dental profession is to stand in the future on its ability and cleverness

*Read before the American Association of Dental Editors, New Orleans, La., Nov. 2, 1935.

in repairing the loss of human structure due to disease, and if it does not make any concerted effort or sacrifice to discover the cause of dental disease, the future of the profession is not very bright; but such is not the case.

Since 1913, the Research Commission of the American Dental Association has sponsored and assisted research to the limit of its ability. At the beginning, most of the direct aid was given to dental schools, in order to foster a spirit of research in the young men entering the profession. Gradually, this financial support was withdrawn as the research departments in the schools became better organized and as they were able to obtain additional funds to carry on this work.

At the present time, the Research Commission makes only one grant directly to a dental school. That grant, a very small one, is for the purpose of assisting Theodore B. Beust in his investigations at the University of Louisville. Two other small grants to assist biologic research are made to Johns Hopkins University and to the New York Institute of Clinical Oral Pathology, Inc. These three grants total only $2,200.

In addition to the foregoing, the Research Commission supervises the American Dental Association research at the National Bureau of Standards. This is, as you know, a cooperative project supported by both the Government and the American Dental Association for the purpose of investigation of materials and the technic for using these materials in the practice of dentistry.

MATERIALS AND TECHNICS

I presume that it is almost needless for me to recall the chaos that prevailed in the fields of certain dental materials and technics prior to the time that the National Bureau of Standards became interested in our problems. As an example, I could cite the inlay casting process. The advocates of the low heat technics often considered the users of the high heat technics as almost guilty of unprofessional conduct, and vice versa. The merits of low and high expanding investments were extolled in a similar manner. The casting shrinkage and other physical properties of gold were not accurately known. The same was true of all the accessory materials. The literature was replete with contradictions and evidence of confused thinking. Data and systematic investigation were conspicuous by their absence.

Compare this condition with the situation as regards the inlay technics that are offered today. Dr. Souder, a scientist on the bureau staff who is now chief of the dental materials research laboratory, after an extensive reading of the literature on casting technic, said: "If there is another problem in dentistry in which one can read more and learn less, articulators excepted, I have failed to find it. I am unable to understand the lack of interest by some individuals in consistent fundamental research looking toward the establishment of standards for materials and technics." Someone has used the phrase "proper materials properly used," and that is the motive behind our activity at the National Bureau of Standards.

Then, too, the dentist had long felt that he should have some place where he could obtain unbiased and correct information on the materials that he was using in his health service. He found that place when this cooperative project was formed to study his problems.

RESEARCH COMMISSION'S PROGRAM

The Research Commission is endeavoring to protect the dentist in the purchase and use of dental materials. The

major ideas of our program have long been applied by certain professions, especially engineering. I mean by that that the engineer, in the construction of any device, usually has standards or specifications for the materials that he is using. The reasons for his actions are so elemental that I need not cite them. The reasons apply to the work of the dentist just as much as they do to that of the engineer.

Our present outline of work could be summarized as follows:

1. Trade brands of currently used materials are procured on the open retail market by the Research Commission.

2. A study of the physical and chemical properties of these materials that are significant as far as their dental uses are concerned is made by the research workers at the National Bureau of Standards. This study is supplemented by obtaining opinions and data from the profession.

3. With the foregoing survey as a basis, a tentative specification is formulated and is submitted to dental schools, the government services and the manufacturers for suggestions and criticisms.

4. The director of the bureau then releases the specifications to the Research Commission, which if it approves the specification, presents it to the House of Delegates for consideration. If adopted by the House of Delegates, it becomes the official specification of the American Dental Association. In other words, the dental profession is setting the standards for the materials it is using and is asking the manufacturers to supply materials meeting these standards. This is a considerably different procedure from having the manufacturers determine what the dentist is to use. If the American Dental Association had had in operation for several years a reliable specification for denture materials, the present situation in this field, I believe, would not have existed.

5. The Research Commission then invites the manufacturers to formally certify to the Commission that their products comply with the American Dental Association specifications. If a manufacturer desires to certify his material to the Commission, he must conform to every requirement of the specification and supply certain technical information, such as a description of the test methods and of the instruments used, the name of the individual making the tests and a sample of the test data.

6. After this procedure has been complied with, the Research Commission procures on the open market a sample of the material that is being certified. This sample is tested by our research associates at the National Bureau of Standards to ascertain whether it complies with the specifications.

7. If the material does comply with the requirements of the specification, the certification is accepted and the product is included in a list of materials that have been similarly certified to the Research Commission by the manufacturers. This list is published in the various journals.

8. If the material does not comply with the specification, the certification is rejected. The manufacturer is asked either to remove the guarantee label from the package or to modify the material so that it will comply with the requirements of the specification. In all but one instance, the manufacturer cooperated with us in such a manner that the situation was corrected in an amicable fashion. In one case, the matter was brought to the attention of the Federal Trade Commission. The manufacturer then agreed to delete the guarantee statement from his package. All of these matters have been adjusted without the payment of any legal fees.

SPECIFICATIONS AND LIST OF CERTIFIED PRODUCTS

The American Dental Association has to date eight specifications in operation; namely, those for amalgam, inlay casting investments, impression compound, inlay casting wax, inlay casting golds, mercury, wrought gold wire and cementing medium (zinc phosphate cements).

I have here for distribution among you lists of materials that have been certified to comply with the foregoing specifications, with the exception of the cements, which are now in the process of certification. I might add that this list is being continually checked by our research associates at the Bureau. In fact, one man devotes almost his entire time to this check testing.

MANUFACTURERS' COOPERATION

A glance at this list will show you that almost every reputable dental manufacturer is cooperating in our program. Probably the main reason for this active assistance of the manufacturer is the support that the profession in general and you in particular have given this work. Many dentists are becoming more discriminating in buying supplies; and enough of them are using this list of certified products as a buyer's guide and are looking for guarantee statements on the package to the effect that the material complies with the A. D. A. specifications, to make it worth while for the manufacturer to go to the expense of testing his materials.

Many dentists are also developing the habit of asking very embarrassing questions of the manufacturers, such as "Why isn't this or that material on the list of certified products?" Such conditions impress the sales people and convince the executives of the companies that it is good business to test and guarantee their materials. I believe that every one of the leading dental manufacturers has a division devoted to research and testing. While not all of this can be traced to the bureau activity, a large portion of it can.

Again, I want to cite a specific example, the case of the zinc phosphate cements. After the publication of the work of the fellowship on zinc phosphate cement, three concerns developed entirely new cements, while three others modified and improved their old products. All are using some of the apparatus and test methods that were developed in the study.

ADVERTISING

The Research Commission's present policy regarding advertising is practically restricted to advertisements containing statements involving the commission's reports or policies or the specifications. We have on occasion called to the attention of the profession certain false claims, such as the labeling of an alloy as being a gold alloy when, in fact, it did not contain gold in appreciable quantities. All such instances were adjusted to our satisfaction by the simple procedure of asking the manufacturer to correct the situation.

DENTAL SCHOOL COOPERATION

Several dental schools have installed sufficient equipment and personnel to conduct courses on the physical properties of dental materials.

One of the recommendations contained in the recent report of the curriculum survey committee of the American Association of Dental Schools was that such a course be made an integral part of the dental school curriculums. Many schools are using certified materials in their clinics and laboratories.

To support the work of the Commission, when possible buy materials that are on the list of certified products. Use

it as your buyer's guide. Look for the guarantee statement on the package saying the material complies with the American Dental Association specification.

The Research Commission hopes to continue to conduct the work in such a manner as to merit your continued support.

PROCEEDINGS OF THE FIFTH GENERAL MEETING OF THE AMERICAN ASSOCIATION OF DENTAL EDITORS*

ABSTRACT OF THE MINUTES

THE American Association of Dental Editors, representing sixty-seven nonproprietary dental publications, met in New Orleans at the Roosevelt Hotel, Nov. 2nd, 1935, for an all-day and evening meeting. The sessions were called to order by the president, John E. Gurley, and the following program was presented:

Morning session: 1. Minutes of the Fourth annual meeting were read and approved. 2. The secretary's report was accepted. (The report included the recommendation of a formal ballot for the eleven new members previously elected by informal mail ballot, who were elected unanimously.) 3. Report of treasurer showing credit balance of $407.84 was accepted and filed. 4. The president, Dr. Gurley, gave an informal report (formal address deferred to evening session). 5. Reports of committees: (*a*) executive, (*b*) by-laws, (*c*) cooperation, (*d*) current dental literature, (*e*) advertising, (*f*) nominating, were accepted and all filed excepting (*c*), (*d*) and (*e*), which were referred to the executive committee.

Afternoon session: The following papers were read: 1. "The Value of the American Dental Association": (*a*) "The Research Department," by C. T. Messner; (*b*) "Editors and the Campaign for Reform in Proprietary Dental Medicines," by S. M. Gordon; (*c*) "The Bureau of Public Relations," by L. M. Morrey. 2. "The Survey of the Dental Curriculum," by L. E. Blauch. 3. "Judging Editorials," by W. C. Graham. 4. "Cooperation," by C. N. Johnson.

Twenty new members were elected and there was election of officers for 1935-1936.

Evening session: Dinner preceded the evening session. F. M. Casto brought greetings from the American Dental Association. The following spoke representing other organizations: (*a*) A. R. MacDowell, for the American Association of Dental Schools, (*b*) William R. Davis, for the American College of Dentists, (*c*) Sydney I. Tiblier, for the Board of Dental Examiners. To these speakers William J. Gies, vice-president, responded, later introducing the president, Dr. Gurley, who gave his presidential address, held over from the morning session. Meigs O. Frost, editor of the *Times-Picayune,* of New Orleans, spoke on "The Fine Art of Making a Professional Journal Readable." The final report of the Executive Committee was presented.

EXTRACTS

President's address: One great problem confronting dentistry today is the assimilation of knowledge already available, and to this end the dental schools are struggling with the problems of the curriculum and the organized profession with

*New Orleans, La., Nov. 2, 1935; Otto W. Brandhorst, St. Louis, Mo., Secretary.

the problem of its further dissemination.

Dental journalism was not begun in what we today would consider the most auspicious environment. The business men of our (dental) family used it primarily as a medium of spreading the gospel regarding their wares. As long as honesty prevailed, we are satisfied with the beginning. But as the members of our profession came to have a more thorough understanding and made a better application of the knowledge thus gained, we developed a new desire concerning our literature. It did not seem desirable that we should leave it either directly or indirectly in the hands of our business men. We are grateful for the developments of the past, but, as far as the future is concerned, we see the need of producing our literature in a strictly professional environment. If there is conflict in this effort, it is not brought on by the profession. Should not the profession be responsible for disseminating that which it has created?

There are, among others, two functions of the American Dental Association which stand out preeminently: the Research Commission and its activities conducted jointly with the Federal Bureau of Standards and the Council on Dental Therapeutics. Consider the advances made in producing alloys, waxes, investment compounds, etc., and where would we be today as regards therapeutics and so-called therapeutic agents, were it not for the effective work of the Council on Dental Therapeutics? There is the clinching argument for professionally owned literature. We need the truth, and we need reliable therapeutic agents, which we can have only if they have been tested and proved.

Honest advertisers and manufacturers want their news truthfully presented. It is our privilege to require that as far as they come within the scope of one or the other, all products advertised must meet the requirements of the Research Commission or be accepted by the Council on Dental Therapeutics. Action has already been taken by this body relative to the latter, which means that only such articles as have been accepted by the Council can be advertised in our publications. We should take the same stand relative to the Research Commission.

We have previously taken action relative to the placement of advertisements in our journals; namely, that they be confined to the back pages, and we should adhere to it.

OFFICERS AND COMMITTEES, 1935-1936

Following are the officers and committees for 1935-1936:

Officers: President, William J. Gies; vice-president, C. N. Johnson; secretary and treasurer, O. W. Brandhorst; editor, Grace Rogers Spalding.

Committees: 1. Advertising: C. W. Freeman, chairman; V. D. Irwin and George E. Morgan. 2. By-laws: Walter Hyde, chairman; Gerald D. Timmons and W. A. Wilson. 3. Cooperation: U. G. Rickert, chairman; William R. Davis, C. S. Foster, A. Malcolm Smith and A. F. Weeks. 4. Current dental literature: T. F. McBride, chairman; Ingo Hackh and J. H. Kauffmann. 5. Dental-student publications: E. H. Siegel, chairman; R. L. Dunn and Joseph L. Watters. 6. Executive: O. W. Brandhorst, chairman; William J. Gies, John E. Gurley, C. N. Johnson and Grace Rogers Spalding. 7. Membership: C. W. Koch, chairman; S. D. Harris and F. J. Reichmann. 8. Nomination: Leroy M. S. Miner, chairman; E. A. Thomas and L. E. Van Kirk.

ANNOUNCEMENT

The sixth general meeting of the American Association of Dental Editors will be held in San Francisco, Calif., in July, 1936.

INNERVATION OF THE TEETH*

By ALTON D. BRASHEAR, A.B., M.S., D.D.S., New Orleans, La.

THE peculiarly selective nature of the distribution of sensations in the teeth makes the subject of innervation of the teeth particularly interesting to dentists. A review of the more important contributions on the subject of the sensibility of the teeth clearly shows that the nerves of the pulp are mainly responsible for the conduction of pain, and those of peridental tissue, for touch.

If one studies the anatomic bases of conduction of sensations in the body, it becomes apparent that three varieties of sensation are mediated by different types of nerve fibers: touch by large myelinated fibers (10 microns or larger in diameter), temperature sensations by myelinated fibers of intermediate size, (6 to 10 microns in diameter) and pain by fine myelinated (less than 6 microns) and unmyelinated nerve fibers.

It is the purpose of this paper (1) to examine the mechanism of reception and conduction of pain from the pulp or dentin and (2) to study the distribution and type of nerve fiber in the peridental tissue and to see what basis we have for believing that nerve fibers in this tissue are responsible for sensations of touch.

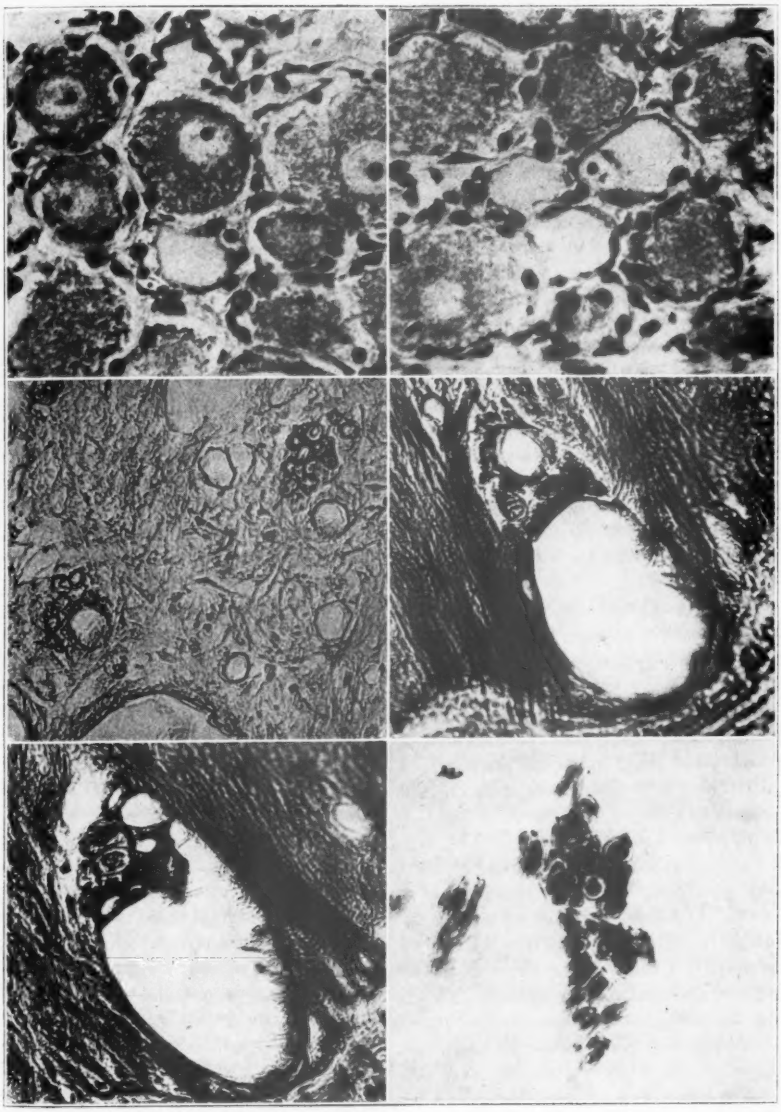
*From the Department of Anatomy, University of Rochester, School of Medicine and Dentistry and the Louisiana State University Medical Center.

*Read before the Section on Histology, Physiology, Pathology, Bacteriology and Chemistry (Research) at the Seventy-Seventh Annual Session of the American Dental Association, New Orleans, La., Nov. 5, 1935.

PAIN

When mechanical, chemical or thermal stimuli of sufficient intensity are applied to the dentin or a vital tooth, sensations of pain are evoked. This high sensitiveness of the dentin suggests the presence of nerves, and, for a long time, histologists have been trying to demonstrate the existence of these nerves. This appears to be a simple matter. All that seems necessary is to treat the dentin with stains having a peculiar affinity for nerve tissue and thus prove or disprove the presence of nerves. In reality, the staining of dentinal nerves, if any are present, is an exceedingly difficult problem of histologic technic.

Histologic methods, which have been devised especially for the study of teeth in general, have to do with the removal from these tissues of the calcium salts, and, unless these salts are removed, it is impossible to cut dentin into the thin sections necessary for study. Decalcification methods depend for their efficiency on the solubility of the tertiary phosphate and carbonate of calcium in strong acid solutions. Most decalcification methods are equally efficacious and satisfactory in that they remove the inorganic material from the teeth and leave the tissue softened and in the proper state for cutting. The majority fail because the strong acid solutions sear the soft tissues in the calcified structure, causing so much destruction and shrinkage as to make the normal structure and relations of the cellular tissue highly conjectural. This is notably



Above: Left: Typical small cell of gasserian ganglion undergoing chromatolysis following extirpation of pulps of cats' teeth. (Thionin stain.) Right: Two cells of same type undergoing chromatolysis. (Thionin stain.) Center: Left: Section of normal pulp of cat tooth, showing typical nerve fiber bundles (upper right and lower left hand corners). The largest fibers measure about 9 microns. (Ranson pyridine silver stain.) Right: Section of peridental tissue of cat. Close examination will reveal a cross-section of typical large nerve fiber measuring 11 microns. (Modification of Ranson pyridine silver method.) Below: Left: Section of peridental tissue of cat. The cross section of the large fiber can be clearly seen, measuring 13 microns. (Modification of Ranson pyridine silver method.) Right: Section of inferior dental plexus of human peridental tissue. This plexus was taken from tissue adhering to the surface of a root of a freshly extracted tooth. Nerve fibers of all sizes can be seen including one measuring over 14 microns. (Ranson pyridine silver stain.) (×430.)

true when we come to consider the termination of nerve fibers of the pulp and their relation to the dentin.

Further, the presence of the metal salts (silver and gold stains) that impregnate nerve tissue affects connective tissue fibrillae similarly, so that the latter can hardly be distinguished from unmyelinated nerve fibers. For instance, von Korff's fibers running between the odontoblasts lend confusion to the picture. In addition to these difficulties, it must be kept in mind that a dentinal tubule has an average diameter of about 2 microns, and therefore, since most of the tubule is occupied by Tomes' fibers, an accompanying nerve fiber can be only a fraction of a micron thick.

With these difficulties in mind, the present work was undertaken, to attempt to show the position of nerve fibers in the teeth. Freshly extracted normal young teeth were obtained from the Rochester Dental Dispensary and cut into blocks, which were fixed by special methods required by the various staining technics to be used, or in 10 per cent formalin or Zenker's solution.

A wide variety of acid solutions were used for decalcification of these blocks of tissue. The acids used were selected, according to their calcium solubilities, from Seidell's "Tables of Solubilities of Inorganic and Organic Compounds." Various percentages of these acids were used, as well as the combination of acids with fixing fluids. The following acids and acid combinations were finally used:

1. Five per cent nitric acid.
2. Two per cent nitric acid.
3. One per cent nitric acid in 7 per cent lactic acid.
4. Two per cent nitric acid in 10 per cent formalin.
5. Five per cent nitric acid in 10 per cent formalin.
6. Five per cent nitric acid in 70 per cent alcohol to which was added 1 per cent phloroglucin.
7. Thirty-three per cent formic acid (original Mummery method).
8. Ten per cent formic acid.
9. Five per cent formic acid in 70 per cent alcohol.
10. Five per cent trichloracetic acid.
11. Five per cent acetic acid.
12. Ten per cent citric acid.
13. Twenty per cent sodium citrate in 10 per cent formalin.
14. Magnesium citrate.
15. Five per cent hydrochloric acid in 70 per cent alcohol.

The fixed tooth sections with the pulp tissues intact were decalcified in the above-named acid solutions. Mechanical as well as chemical tests (ammonium oxalate plus ammonium hydroxide) were used to determine when the tissues were decalcified. Tissues were always washed well and neutralized with a 5 per cent solution of sodium sulfate or a saturated solution of lithium carbonate.

Various standard methods were employed in staining these sections of decalcified teeth. The majority of methods were of the block staining type. The methods finally used were: 1. Hewer's[1] modification of Ranson Pyridine Silver method. 2. Huber and Guild's[2] (1913) adaptation of the Ranson method. 3. Bielschowsky's technic. 4. Mummery's original gold chloride method. 5. Stewart's[3] modification of the Mummery method. 6. Cajal's technic. 7. Ranvier's formic method.

1. Hewer, E. E.: Development of Nerve Endings in Human Foetus, J. Anat., 69:369 (April) 1935.

2. Huber, G. C., and Guild, S. R.: Observations on Peripheral Distribution of Nervus Terminalis in Mammalia, Anat. Rec., 7:253-272, 1913.

3. Stewart, D.: Some Aspects of Innervation of Teeth, Proc. Roy. Soc. Med. (Sec. Odont.), 20:55-66 (Aug.) 1927.

In all the technical procedures described, special precautions were taken to insure the best results. Chemically clean and dry glassware was always used, and fresh solutions were prepared on each occasion. At each change of any solution, clean glassware was used.

A number of serial sections were cut at 10 microns from the tissues stained in blocks. It is important to have serial sections when looking for nerve endings, as appearances can be most misleading from oblique sectioning of nerve trunks when the latter are altering their plane of direction.

It is not necessary to go into detail regarding the individual steps of each staining method. It is worth while mentioning that the best results were obtained with the Ranson,[4] gold chloride and Bielschowsky methods on sections which were decalcified by means of 10 per cent formic acid, 5 per cent nitric acid in phloroglucin or the lactic-nitric acid combination. Good results were also obtained by use of above-named staining methods on any of the formic or nitric acid decalcification series.

In the best sections used for microscopic examination, the nerve fibers were seen in the pulp as three or four medullated trunks. These finally broke up under the odontoblastic layer into nonmedullated fibers, which were seen to end as free nerve endings around the odontoblast or pass between the odontoblasts and end around the odontoblastic process. No fibers that could be distinguished as nerve fibers were seen to enter the dentin of the tooth.

In addition to the foregoing technics, several new methods for demonstrating nerve fibers of the tooth have appeared in the literature. Among the more important of these is the method suggested by J. Staz[5] (1934), of South Africa. This method calls for the use of silver bromide impregnation of decalcified sections followed by exposure of these impregnated tissues to the roentgen rays, which are supposed to act as a catalyst on the silver bromide and cause a deeper and more even reduction of the silver. The technic described by this author was carried out very carefully. Modifications of his method in regard to time or impregnation of silver bromide and exposure to the roentgen rays were also carried out. The usable sections prepared by this method did not reveal any disposition of nerve fibers other than that already described.

Another method, which at present is claiming the attention of students of this problem of dental innervation, was tried, the so-called electro-osmosis method of Tojoda[6] (1934). According to his investigations, dentin is innervated by fine nonmedullated nerve fibers. The purpose of his method is to remove by electrolysis the excess acid left in the tissues after decalcification and then impregnate with gold or silver. An attempt was made to duplicate the Tojoda method, but with unsuccessful results. Decision is reserved on results of this method until a new electro-osmosis apparatus has been completed at the direction of Dr. Tojoda.

When the mass of observations, sketched here so briefly, are analyzed carefully, one is led to believe that sensory nerves of the pulps of teeth end freely about the odontoblasts, and between these cells and the dentin.

4. Ranson, S. W.: Structure of Spinal Ganglia and Spinal Nerves, J. Comp. Neurol., 22:159-175, 1912.

5. Staz, J.: Silver Bromide as Pulp Stain, J. D. Res., 14:347 (Oct.) 1934.

6. Tojoda, M.: Die Innervation des Menschlichen Zahnbeins, Deutsche Zahnarztl. Wchnschr., No. 28, 611-615; No. 29, 670-673 (July) 1934.

At this time, we find that the anatomic bases for pain conduction have been receiving active attention. Pain conduction in the trigeminal nerve and in other parts of the body has been shown to be conducted by the small nerve fibers, both myelinated and unmyelinated. (Windle,[7] 1926; Ranson,[8] 1931; Ranson and Davenport,[9] 1931; Davenport and Ranson,[10] 1931, and others.) Heinbecker, Bishop and O'Leary[11] (1933) have presented evidence that the small myelinated nerve fibers are predominately concerned in the phenomena of pain conduction.

Histologic examination of the stem fibers entering the tooth were made both in the cat and in man. Observations on the best pyridine silver and osmic acid preparations of pulps of these teeth showed that the largest nerve fibers were between 8 and 10 microns in diameter. Actual counts of these fibers showed that between 50 and 64 per cent of the fibers were 6 microns or less in diameter. A few unmyelinated fibers are present.

Any mild thermal, mechanical or chemical stimulation of the dentin of a normal vital human tooth usually results in a painful sensation and no other. The fact that we do not find any large nerve fibers in the pulps of teeth suggests the selective nature of sensation from the pulp. With these facts well established, we are able to apply methods of experimental research to this problem to determine the type of nerve cell from which these pain conducting fibers arise. It is well known that, in the spinal nerves, the unmyelinated and probably the small myelinated nerve fibers arise from the small cells of the spinal ganglion. (Ranson,[12] 1912, 1931.) It has been previously stated that both types of fibers may be concerned with pain conduction.

In a series of cats, I extracted the pulps of teeth, taking great care not to disturb the other tissues. After time allowed for axon reaction to take place, Nissl series sections (stained with thionin) were made of the trigeminal ganglion and these ganglions were examined for alterations. The majority of the reacting cells of the ganglions were of the small or medium type and are of a size similar to that of cells that have been shown to give rise to pain conducting fibers in the spinal nerves.

It has been shown by a review of the literature that there is a good reason for believing that pain is mediated by sensory fibers of the smallest diameter. Let us now consider the mechanism of reception of painful impulses from the rest of the body. Adrian[13] (1928) expressed the current opinion of neurologists that there are special receptors and conductors for pain and such evidence at hand indicates that free nerve endings in the corium, in the cornea of the eye and in free endings elsewhere are responsible for pain reception. It is unnecessary for them to reach the surface of the body: they are stimulated through a medium of other non-

7. Windle, W. F.: Distribution and Probable Significance of Unmyelinated Fibers in Trigeminal Nerve of Cat, J. Comp. Neur., 41:453-476 (Aug.) 1926.

8. Ranson, S. W.: Cutaneous Sensory Fibers and Sensory Conduction, Arch. Neurol. & Psychiat., 26:1122-1140 (Dec.) 1931.

9. Ranson, S. W., and Davenport, Helen K.: Sensory Unmyelinated Fibers in Spinal Nerves, Am. J. Anat., 48:331-353 (July) 1931.

10. Davenport, H. A., and Ranson, S. W.: Ratios of Cells to Fibers and Myelinated to Unmyelinated Fibers in Spinal Nerve Roots, Am. J. Anat., 49:193-207 (Nov.) 1931.

11. Heinbecker, P.; Bishop, G. H., and O'Leary, J. L.: Pain and Touch Fibers in Peripheral Nerves, Arch. Neurol. & Psychiat., 29:771-789 (April) 1933.

12. Ranson, S. W.: Footnotes 4 and 8.

13. Adrian, E. D.: Basis of Sensation, New York: W. W. Norton & Co., 1928.

nervous elements. Stopford[14] (1930) has stated that "in the case of pain spots, histology has tended to suggest that there are no special receptors, and that the termination is by free endings of the fibers."

The evidence presented in this paper and the correlation of this evidence of reception of painful impulses in the teeth with the reception of painful impulses in the remainder of the body suggests, in the case of the tooth pulp, that painful stimuli are conducted by nerve fibers of smallest diameter which arise from small and medium sized cells of the trigeminal ganglion. The nerve fibers end in the odontoblast layer and beneath the dentin in free, beaded terminations.

The development of nerve endings in the various tissues of the body is so closely bound up with the histogenesis of those tissues that any investigation of the former must include the latter, more particularly as the developing nervous elements are known to be influenced by their surroundings (Hewer,[1] 1935). Therefore, until this phase of the study of the innervation of the teeth has been completed, opinion as to the exact location and type of nerve endings in the teeth is reserved.

TOUCH

It is obvious that response of teeth to pressure is fairly acute. The little evidence that we have from pulpless teeth suggests that the nerves of the pulp have nothing to do with touch, and this must be transmitted along nerves of the peridental tissue (Frankel,[15] 1871; Stewart,[3] 1927). The fact that cuspids, which usually have a longer root, have a higher minimum pressure than other teeth indicates that touch must be elicited from the peridental tissues. (Stewart,[3] 1927.)

Fortunately, our general knowledge of the functions of peripheral nerves has been greatly increased during recent years by the work of Head (1920), Adrian[13] (1928), Stopford[14] (1930) and other investigators, and it is now possible to begin the application of their findings to the special problem of dental innervation. Evidence at hand indicates that touch is conducted over myelinated nerve fibers of the largest diameter. (Droegemueller and Davenport, Ranson[16] [1933], Gasser and Erlanger[17] [1929] and others.)

The nature of the peridental tissues and their close attachment to the roots of teeth and to the surrounding bone made it necessary to work with this tissue in place. Blocks of mandibular and maxillary bone with the teeth and peridental tissues intact were removed from the jaws of cats. These tissues were subjected to Huber and Guild's[2] (1913) adaptation of the Ranson pyridine silver technic for decalcified tissues and to a modification of this technic. Sections were cut at right angles to the long axis of the tooth and close to the apex of the tooth to show main bundles of fibers entering this tissue. Fragments of human peridental tissues, which sometimes adhere to the root of a tooth after extraction, were also obtained and treated by Ranson original pyridine silver method and Hewer's modification of the Ranson technic.

Microscopic examination was made of the sections of the peridental tissue of the

14. Stopford, J. S. B.: Sensation and Sensory Pathways, New York: Longmans, Green and Co., 1930.

15. Frankel, P.: Berl. Klin. Wchnschr., 1871, p. 367.

16. Ranson, S. W.: Cutaneous Sensation, Science, 78:395 (2027) 1933.

17. Gasser, H. S., and Erlanger, J.: Rôle of Fiber Size in Establishment of Nerve Block by Pressure or Cocaine, Am. J. Physiol., 88: 581 (May) 1929.

cat. Bundles of nerve fibers were seen to enter the peridental tissues in company with the blood vessels. These bundles contained from eight to twenty medullated fibers. Some bundles of nerve fibers could be seen entering the peridental tissue through the alveolar bone. Nerve fibers of all sizes were seen in these sections. The largest fibers measured from 10 to 12 microns. Estimate of these fibers indicated that about 20 per cent of the nerve fibers in the peridental tissue surrounding a tooth of the cat were 10 microns or larger in diameter. The rest of the fibers were observed in about equal amounts, with no great predominance of either small or medium sized fibers.

Only one good section of human peridental tissue was secured and the best preparation of this tissue showed that it contained a branch of the dental plexus. This fascicle contained nerve fibers of all sizes. Although it was impossible to obtain the percentage of fiber types present, one fiber in the section measured 14 microns and another 12 microns. At least three fibers observed were 10 microns in diameter. The other fibers varied in size, with no great predominance of one type over the other.

The presence of nerve fibers of all sizes in the peridental tissues should lead us to expect other sensations to be elicited from this tissue besides touch. The sense of pain is not easily aroused in the peridental tissues, but when it is aroused, this tissue is as painful as is usual of tissues, as is shown in acute pericementitis. It was not possible in any section studied to see the type of nerve endings in the peridental tissues.

The conclusion follows that there are good reasons for believing that through its supply of nerve fibers of all sizes, the peridental tissue becomes the organ of touch of the tooth, as well as responding to other stimuli.

INTRAVENOUS METHOD OF REVERSING THE PROCESS OF ANESTHESIA*

By WALTER V. MACGILVRA, D.D.S., Worcester, Mass.

THE subject of this paper would be more appropriately presented under the title "Further studies in the use of intravenous injections of twentieth normal hydrochloric acid for the threefold purpose of: (1) lowering thresholds of stimulation, (2) stimulating respiration and (3) elevating blood pressure in cases of postoperative collapse following general anesthesia."

Subsequently to the presentation of a preliminary report[1] on our verification of and observations on the discovery of Pearl L. Moorman, medical technician of the Duncan Laboratories, Joplin, Mo., and the sequences of its successful clinical

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1. MacGilvra, W. V., and Ellison, Alfred: Palinesthesia: Preliminary Report on Effects of Recall Acid as Means of Recovery and Restoration to Sensibility, unpublished data. MacGilvra, W. V.: Story of Palinesthesia: Effects of Recall Acid as Means of Recovery to Sensibility, Harvard D. Rec., 8: 1-4 (Jan. 31) 1934.

use to correct grave symptoms in a case of overdose of basal anesthesia, wide publicity was given, which in turn provoked lively discussion, led chiefly by Shambaugh and Boggs.[2]

A brief review of the first clinical case may show cause for our early enthusiastic hope that a promising remedy, for emergency use, was somewhere in sight.

This case furnished its own control, the patient undergoing operation twice in thirty-five days, basal anesthesia tribromethynol (avertin) being used on both occasions. The status of health of the patient on the dates of operation was far from being identical.

The condition of this patient on the date of the first operation may be compared to that of a normal adult having an acute appendicitis. At the time of the second operation, after several weeks of general peritonitis complicated by cellulitis of the abdominal wall, the status of health was very different.

From an anesthetic standpoint, the case had, in thirty days, changed from a good to a poor anesthetic risk.

By virtue of a series of circumstances and notwithstanding the great change in the anesthetic risk, on the occasion of the second operation, the patient received a dose of avertin on the basis of his weight at the time of admission nearly five weeks previously, and not on the basis of his actual weight at the time. Therefore, in all probability, he was given a dose somewhat in excess of 100 mg. per kilogram of body weight; whereas, he had received but 90 mg. per kilogram before appendectomy, the first operation. The second operation, incidentally, was merely an incision in the abdominal wall to increase drainage.

2. Shambaugh, Philip, and Boggs, Robert: Effect of Intravenous Hydrochloric Acid upon Narcosis in Dogs, Proc. Soc. Exper. Biol. & Med., 31:7 (March 31) 1934.

Embarrassing as it is to admit the error, the patient was a victim of an ill-advised dose.

At operation, the patient, as might be expected, was moribund. Nor was this my judgment alone, the opinion being shared by every member of the staff present.

The patient presented the following symptoms: deep cyanosis, clear air ways, rapid, shallow respiration, barely perceptible tidal volume, high pulse rate of feeble quality, low blood pressure, very low pulse pressure and complete lack of muscle tone.

DATA ON CASE 1

First Operation.—June 20, 1933, appendectomy was performed on the patient, a man, aged 50, weight 142 pounds, height 5 feet 4 inches. A basal dose of 90 mg. per kilogram of body weight was given; i.e., avertin, 5.8 c.c.; water, 232 c.c. The preanesthetic pulse was 80. A preliminary hypnotic of morphine, one-sixth grain and atropine, one-one hundred and fiftieth grain, was given. Gas-oxygen anesthesia was superimposed. The duration of the operation was one hour and ten minutes; total duration of unconsciousness, two hours and thirty minutes.

Second Operation.—July 25, 1933, an incision was made to increase drainage. The basal dose was 95 mg.: avertin, 6.2 c.c.; water, 247 c.c. The preanesthetic pulse was 120. There was no preliminary hypnotic and no anesthetic superimposed. The duration of the operation was fifteen minutes; total duration of unconsciousness, one hour and seven minutes.

After the second operation, 8.6 c.c. of tenth normal hydrochloric acid was given intravenously.

The difference in orientation time was one hour and twenty-three minutes.

Following the injection of the first few drops of hydrochloric acid, there was an immediate increase in tidal volume and the chain of returning reflexes began in eight minutes, continuing steadily until, at the ex-

piration of thirty-five minutes, the patient was fully conscious, a thing unusual after so large a basal dose of avertin.

So satisfactory was the outcome of this first attempt, so far reaching were the results, and so promising appeared the future in similar attempts, that it was decided to present the subject to Leroy M. S. Miner, dean of the Harvard University Dental School, and to enlist the aid of the school in continuing research to bring out the facts surrounding this phenomenon. This aid sought from Dr. Miner was immediately given, and, through him, the cooperation of the Harvard Medical School was enlisted to make a preliminary survey of the problem. In connection with this research, a committee was formed of the faculties of the Harvard Medical and Dental schools.

It was my privilege to share in the work of a subcommittee which conducted the preliminary survey of the problem, a summary of whose work disclosed the facts tabulated as follows:

Cardiac depression, central:

Dog—Blood pressure level an important factor where blood pressure essentially the same. Depression of heart is increased after administration of hydrochloric acid, 10-20 per cent.

Cat—Same as dog.

Blood pressure:

Dog—Not raised by administration of hydrochloric acid (?) Anesthesia.

Cat—Raised from 100 to 128 mm. of mercury.

Cat—No artificial respiration; ether.

Vagal response:

Slightly greater (5-10 per cent) after administration of hydrochloric acid.

Peripheral vagal response:

Also (5-10 per cent).

Femoral blood pressure:

Raised—response greater (10-20 per cent) after administration of hydrochloric acid.

Blood pressure:

Steady, slow rise after administration of hydrochloric acid.

Cortex:

Cat (dial) threshold, before administration of hydrochloric acid: 8:5-9; after: 8-8:5.

Monkey (ether) face: before: 9.0-9.5; after: 9.5-10. Arm: before: 9.5-10; after: 10. Leg: before: 8.-8.5; after: 8.5-9.

Spinal reflexes (Cor. ext.):

2 Cats (decerebrate): Definite lowering of threshold and increased response (30 per cent).

Respiratory center:

100-300 per cent.

Cardiac depression—peripheral:

Dog (ether): Blood pressure level most important factor—depression increased after administration of hydrochloric acid, pulse and blood pressure particularly increased.

It is evident from the foregoing that these experiments, while roughly quantitative, show a lowering of the threshold for electrical stimulation, in numerous portions of the nervous system, tested on several species of animals under various types of narcosis. The respiratory center was strongly affected, the tidal volume being greatly increased, while the blood pressure increased gradually and was sustained.

In contrast with the expriments reported by Shambaugh and Boggs,[2] in whose experiments the animals were merely anesthetized and not operated on, it may be pointed out that, in clinical practice, the patients here studied are human beings all of whom have undergone surgical operations, and in whom the stimulation of surgical trauma is present at the time of acid injection. Even though the threshold for stimulation is elevated by reason of anesthesia and shock, the lowering of the threshold by virtue of the acid effect permits the stimulus present free access to tracks, synapses

and centers previously incapable of transmission and lacking in sufficient irritability to react to stimulation. That synapses are affected by intravenous injection of hydrochloric acid was suggested in a casual experiment not scheduled on our program in which a co-worker in the same laboratory engaged on a wholly unrelated problem had paralyzed the synapses in a cat by using nicotine. After completing his own work, he turned over the animal to us. The acid was injected and the paralyzed synapses became immediately functional. Nicotine was again injected and the synapses became paralyzed, and again acid established their integrity.

Results of the foregoing experiments would tend to throw doubt on any conclusions that the intravenous injection of dilute hydrochloric acid is without effect.

The slides shown illustrated graphically the condition of the patient previous to, and after, acid injection, all in this series receiving hydrochloric acid in a twentieth normal concentration. The volume of acid injected varied in individual cases, each patient receiving only sufficient to produce a favorable change in his condition. The effect produced depends less on the speed of injection than on the volume injected. Elapsed time during injection has varied from one to twenty minutes.

Some of these patients received other forms of stimulation, coincident with the intravenous injection of acid, and this may be explained as necessary since it is admitted that our work is purely experimental and we could not in justice to the patient escape the use of recognized emergency aids. It is felt that because of the effect of intravenous injection of the acid, more pronounced results were obtained from the other stimulants used.

As far as general anesthesia is concerned, the members of this society are perhaps more largely interested in nitrous oxide-oxygen, than in ether, and basal anesthetic agents, though all have a proper place in your practice, and you would doubtless be interested to learn of what use intravenous injection of hydrochloric acid might be in the case of gas anesthesia.

As yet, we have had no opportunity to use this method in any case of overdose with the anesthetic gases. Experimental work with rabbits shows spectacular results, even when the animal is anesthetized to the point of respiratory failure. It must be admitted that this is true even without use of the acid, if one is successful in reestablishing respiration. The point is that injection of the acid into the circulating blood not only lowers the threshold for the respiratory center to receive stimulation, but, by its reaction with the bicarbonates of the plasma, enriches the blood with an increased carbon dioxide, the specific stimulant desired. The proper time for its use is early in the period of respiratory cessation and before heart failure. No time should be lost in giving it, if respiration by the usual means cannot be promptly reestablished.

In the event of asphyxial respiratory failure from overdose of an anesthetic gas in a human being, the same results may be predicted, and even though the respiratory function were to be reestablished and continued for so short a time as five minutes, the increase in tidal volume would eliminate practically all of the anesthetic agent, thus removing the hazard.

The fate of the dilute solution of hydrochloric acid injected into the blood stream is explained by Wright,[3] as follows:

I. Physico-Chemical Reactions. 1. When any non-volatile acid like lactic, phosphoric,

3. Wright, Samson: Applied Physiology, Ed. 4, London: Oxford University Press, 1932.

or sulphuric acid enters the blood stream, it at once interacts with the bicarbonate present in the plasma as follows:

(i) HL $NaHCO_3$ NaL H_2CO_3
(Lactic acid) (Sodium lactate)

In the case of lactic acid, sodium lactate and carbonic acid are formed. The advantage of this reaction to the body is clear. Lactic acid is a strong acid, which means an acid which dissociates freely and gives rise to many H ions, and thus makes any solution in which it is present very acid: it is also a non-volatile acid which is excreted slowly in the urine. By the interaction with sodium bicarbonate it is converted into a neutral salt and H_2CO_3 is liberated. Now H_2CO_3 is a much weaker acid, giving rise to fewer H ions; furthermore, it is a volatile acid which is readily eliminated in the lungs. Sodium bicarbonate has therefore acted as a buffer substance; it has caused H ions to be "mopped up," fewer are left in the solution, and reaction of the blood has altered to a much slighter extent than otherwise would have been the case. This is why the term "alkali reserve" was introduced to describe the bicarbonate of the blood.

It follows that as long as $NaHCO_3$ is present in the plasma, no acid stronger than carbonic can exist in the blood as such.

2. But the acid formed in largest amounts in the body is H_2CO_3 itself, which of course cannot be dealt with by $NaHCO_3$. H_2CO_3 is dealt with in the following way:

(ii) H_2CO_3 NaCL $NaHCO_3$ HCL
(iii) HCL KHb KCL HHb
(Potassium salt of reduced hemoglobin.)

H_2CO_3 interacts with the sodium chloride of the plasma to form sodium bicarbonate and hydrochloric acid. On the face of it this reaction seems both meaningless and impossible. Instead of the weak acid H_2CO_3 we have formed the stronger acid HCl, so the H ion concentration of the solution ought to rise still higher. Again, a weak acid like H_2CO_3 cannot displace chloride from its union with Na in NaCl. The explanation is this. An equation like (ii) above can act in either direction if the product of the reaction that would tend to drive the process the opposite way is at once removed. In other words, the equation will go from left to right if the HCl formed is at once removed from the plasma. This actually happens. If blood is exposed to increased tensions of CO_2, the amount of $HaHCO_3$ in the plasma increases and the chloride diminishes in the plasma and increases in the interior of the red blood corpuscles. The HCl resulting from equation (ii), as it is formed in minute amounts, migrates rapidly through the corpuscular wall to be dealt with suitably in the red cell. This is the Hamburger phenomenon, or chloride shift.

Please do not misunderstand the purpose of this paper. It is not intended to be a plea for widespread use of hydrochloric acid as a panacea for all anesthetic faults. It is merely a reference to experimental work already undertaken to determine its value in medicine. You may be assured that I am wholly indifferent as to whether this or some other drug shall ultimately prove to be the answer. We have seen too many failures in our own animal experimentation to believe that the problem is even near complete solution, but the bright spots have urged us to pursue the search.

We believe that ultimately a remedy will be developed that will bring palinesthesia into universal practice. To date, all is experimental.

In our original article,[1] one paragraph has evidently been generally overlooked by all critics of the paper. This paragraph I wish to repeat here: "What may be of greater importance to the public, the anesthetists and surgeons than prompt awakening of patients out of the anesthetic state is that any patient endangered by reason of anesthesia is immediately removed from that danger by the palinaesthesia discovery when it is perfected."

I have made no claim to the effect that palinesthesia has, as yet, been perfected, and we are by no means discouraged by adverse criticism: that was expected and is welcome. Recalling other forward steps in medicine, one is reminded that Pasteur's first public demonstration of smallpox vaccine resulted in the death of fourteen cattle; that Horace G. Wells experienced failure in attempting to demonstrate in Boston that nitrous oxide is an anesthetic agent, and that Morris Richardson of Boston encountered strong resistance in his early effort to persuade the medical profession that appendicitis is an etiologic factor in peritonitis; while, in contrast, most of us can remember the early assurances that "606" (arsphenamine) would banish syphilis from the earth.

It has been suggested by a few that the intravenous injection of even moderate doses of hydrochloric acid diluted to twentieth normal might be distinctly harmful to some individuals, and this may be true unless disproved by further experimental evidence.

It is also true that serum therapy is plagued by its records of fatal anaphylaxis; that arsphenamine has its lethal Herxheimer reaction; that insulin is given not wholly without danger to some, and that all forms of anesthesia, including procaine, have their own unpleasant statistics. But who among you is ready to condemn them entirely, knowing that the lives of many have been made happier because of their use?

Our chief interest is that the principle involved in accomplishing palinesthesia shall be sought for and ultimately perfected for the great benefit that it will bring to that portion of the public who must at some time submit to anesthesia.

DISCUSSION

J. A. Heidbrink, Minneapolis, Minn.: A great deal of interest naturally resulted from the early rumors that a treatment had been discovered with which anesthesia processes might be reversed and anesthetic effects be more quickly terminated. Such treatment, if effective, would doubtless result in the saving of many lives. It is, therefore, somewhat disappointing that Dr. MacGilvra is obliged to abandon the original title to his paper, which implied that these results already had, in a measure at least, been accomplished. Doubtless, Dr. MacGilvra, who was one of the earliest experimenters, is most disappointed because further experimentation indicated that the maximum results hoped for had not yet been accomplished. It is heartening that research is being made in so worthy a field. If, as Dr. MacGilvra contends, intravenous injections of hydrochloric acid lower the thresholds of stimulation, stimulate respiration and elevate blood pressure, it appears that some progress has been made. Some other research workers are not in agreement with Dr. MacGilvra's findings concerning the effects of hydrochloric acid injections following anesthesia in animals on which experiments were made. Shambaugh and Boggs summarize their latest findings as follows[4]: "Observations on guinea-pigs, rabbits, dogs, monkeys and baboons indicate that the intravenous injection of dilute hydrochloric acid is without effect as a means of shortening the recovery period from ether, pentobarbital sodium and tribromethanol narcosis."

Dr. Lundy: I think that Dr. MacGilvra is wrong in his theories and there are a great many others who think so. H. E. Essex, of the Experimental Institute, Mayo Clinic, thinks that, from the results of these experiments, it is quite evident hydrochloric acid is not effective in amytal anesthesia. That is the physiologist's point of view. A physiologic chemist went over the material that has been presented today, and was presented in Indiana and in Boston, with some additions as time goes on.

4. Shambaugh, Philip, and Boggs, Robert: Effect of Intravenous Hydrochloric Acid in Narcosis, J.A.M.A., 102:1912 (April 21) 1934.

and he could see nothing in the interpretation of the data that were presented that would verify the claims that were made. For example, he felt that the p_H of the variation in the blood from the injection of hydrochloric acid in the quantities that were used was not greater than would be found in the normal individuals, and that the amount injected was so small that in the total volume of blood it could not produce the effect. It could not free enough carbon dioxide to produce the effect claimed. Not that there will not be some increase in respiration from a variation in the normal changes in carbon dioxide in the blood stream, but they would not be sufficient to wake the patient or the animal up. From a clinical point of view, I think I could take the same slides that Dr. MacGilvra has presented, and give the same results and show you much more convincingly, to me at least, that the other drugs that were used, for instance, the caffeine, had more to do with sleeplessness than the hydrochloric acid did, and that the injection of epinephrine subcutaneously in the presence of low blood pressure does not raise the blood pressure immediately. In spinal anesthesia, when an extreme fall in blood pressure has been produced, there is no point in injecting epinephrine or anything else subcutaneously. If the effectiveness of the circulatory apparatus is so decreased, it cannot take it up. If the effect cannot be obtained intravenously, it can be had intraspinally, and with much better effect. But if an effect can be obtained intravenously as a rule, intraspinal injection is still more effective. It would be interesting to see whether hydrochloric acid would do the same as ephedrine or epinephrine. It would be more effective. In any animal that is profoundly anesthetized, with fall in blood pressure, and decrease in total volume, any method of increasing depth of respiration and raising the blood pressure will give evidence of a decrease in anesthesia; that is, the patient or animal will temporarily appear to be more lightly anesthetized than before. In the clinical cases, there were measures instituted which should have of themselves produced the same result as was seen here with the hydrochloric acid. I want to show a case of nitrous oxide anesthesia with the blood pressure from the femoral artery, and a normal level from here to the base line (indicating). At this point, an extreme anoxemia is instituted, with the chest torn open and the lungs collapsed so there was no possibility of autoventilation. We see this picture of the blood pressure dropping and going back up again, with many beats of the heart. It goes through one phase and then settles down to a strong pulse pressure with a gradually decreasing blood pressure, until there is not only respiratory collapse, but also stoppage of the heart, which stops by inhibition, and then, with artificial respiration, if the animal can be resuscitated at all, a tremendous effect is evident. In this particular animal, the experiment was repeated, and the animal brought back until blood pressure and pulse rate were normal. An anoxemia is instituted and the heart tends to stop by inhibition. It starts with the final effort to get oxygen, until the blood pressure falls and the heart stops. That is from pure anoxemia and is the typical anoxemia curve. The heart may act in that way in the presence of anoxemia, and I am not sure that this is not what we see in some cases of avertin anesthesia wherein the anoxemia is not recognized because the patient does not go through an acute stage of cyanosis. But the administration of oxygen will bring the patient back to consciousness. Intravenous administration of epinephrine will do the same thing. From Cornell University came sodium rhodanate, and it was supposed to do the same thing, but it does not. We have not been any more successful in the administration of hydrochloric acid than we have been with sodium rhodanate. Nobody would rather have this work prove a success than I, but as far as I can determine, it is not.

NEW CONCEPT OF THE DEVELOPMENT AND CALCIFICATION OF TEETH*

By E. C. McBEATH, M.D., D.D.S., New York City

CLINICAL dental observations, until very recently, have not been in agreement with dental literature. The dates of eruption of the teeth are well established, but certain phases of the old data on calcification are undeniably incorrect. The old tables of Legros and Magitot, Peirce and Black have been copied in the scientific literature of the entire world, but no authority for their compilation has ever been advanced. It is surprising that no one has ever thought it necessary to verify their authenticity or correctness before commending them. Clinical and roentgenographic data collected in our division of dentistry for children on the relative distribution of hypoplastic dental defects have emphasized increasingly the lack of adequate support of the information given in these tables and charts. Some remarkably accurate clinical observations were made by dentists during the last century, but these were not properly recorded and made available.

The latest studies of Logan and Kronfeld[1] establish beyond doubt the time and order of calcification and development of the teeth. As a consequence, we now have scientific data reconcilable with clinical observations. Their investigations were made on twenty-five human jaw specimens ranging in age from at birth to 15 years (nineteen of which were 2 years or under), secured a few hours after death. These specimens were treated to show the undisturbed relation of the overlying soft tissues to the jaws and of the deciduous to the permanent teeth from the earliest development of the permanent germ at birth to the completed resorption of the deciduous teeth and their replacement by the permanent teeth.

They show that the permanent teeth in their entirety are calcified after birth, contrary to the old tradition that the first molar is calcified before birth. Therefore, prenatal management is chiefly effective in protecting the maternal source of tooth building materials and not in determining the quality of tooth structure, as previously maintained. The old chronologic sequence of calcification from the central incisor to the third molar is overthrown and disproved and a distinction is made between the upper and lower teeth as to order of calcification and development. Allowances are made for variations in ages given in connection with tooth development according to variations in birth weight, body development and general state of health, but stress is laid on the constancy of the relative order of calcification and development of the permanent teeth, beginning with the first permanent molar.

*From the Division of Dentistry for Children, School of Dental and Oral Surgery, Columbia University.

1. Logan, W. H. G., and Kronfeld, Rudolf: Development of Human Jaws and Surrounding Structures from Birth to Age of Fifteen Years, J.A.D.A., 20: 379-427 (March) 1933; Kronfeld, Rudolf: Development and Calcification of Human Deciduous and Permanent Dentition, The Bur, March, 1935; First Permanent Molar: Condition at Birth and Postnatal Development, J.A.D.A., 22:1131-1155 (July) 1935; Postnatal Development and Calcification of Anterior Permanent Teeth, ibid., 22:1521-1536 (Sept.) 1935.

Logan and Kronfeld place the permanent teeth in three definite groups, the calcification and development of which take place more or less concurrently. These groups are, in order of their calcification: (1) upper and lower first permanent molars, upper and lower central incisors, lower lateral incisors and upper and lower cuspids; (2) upper lateral incisors, and (3) upper and lower bicuspids and upper and lower permanent second molars. (The third molars are not considered as their calcification begins at a time later than hypoplastic lesions usually originate.)

Charles F. Bödecker contributes charts showing the calcification and eruption of the permanent teeth. (Figs. 1-3.) His discussion follows:

The conception of the calcification and eruption of the teeth as published by Logan and Kronfeld[1] is doubtless more exact than the older views; hence, the new work should replace the old. Charts are more comprehensible than figures and have the further advantage of readily making possible the comparison of the rate of development of individual teeth. Two types of graphs are presented; each has its advantage.

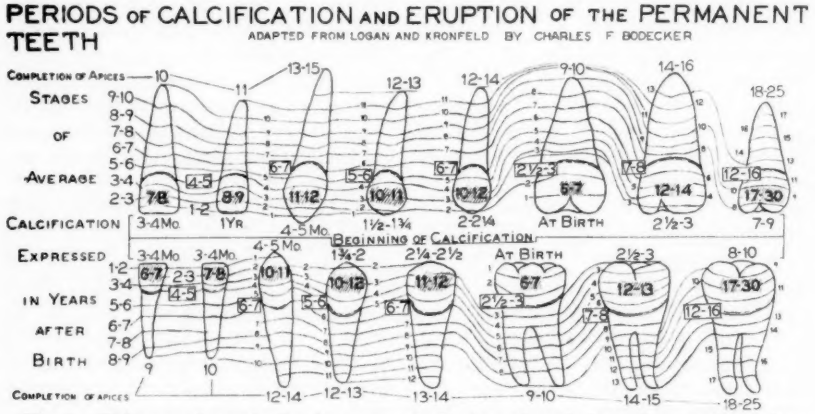
PERIODS OF CALCIFICATION AND ERUPTION OF THE PERMANENT TEETH
ADAPTED FROM LOGAN AND KRONFELD BY CHARLES F. BODECKER
COMPLETION OF APICES
STAGES OF AVERAGE CALCIFICATION
EXPRESSED IN YEARS AFTER BIRTH
BEGINNING OF CALCIFICATION
AT BIRTH
COMPLETION OF APICES

Fig. 1.—Old type of graph showing anatomically formed teeth located on occlusal plane. The shaded figures indicate their time of eruption. The growth lines are difficult to follow.

Postnatal management, nutritional and hygienic, is now more definitely recognized as imperative for the preservation of the permanent teeth and the improvement of the environment of the deciduous teeth. It must be instituted immediately after birth and continued through the adolescent period. Meticulous care is especially indicated during the early years to prevent disease and other conditions that interfere with the normal calcification of the dental tissues.

It is gratifying to believe that many of

2. Hellman, Milo: Nutrition, Growth and Dentition (Tables X to XIV), D. Cosmos 65: 34-49 (Jan.) 1923; Process of Dentition and Effect on Occlusion (Tables VII, IX, XI, XVII), ibid., 65:1329-1344 (Dec.) 1923.

Figure 1 shows the old type of graph in which the teeth are arranged along their occlusal plane, while the growth lines undulate, in order to show the degree of development attained by each tooth at various ages. These lines are rather difficult to follow, in spite of repeating the age figures. Consequently, another type of graph is presented which has the advantage of greater clarity as the age lines are run parallel to each other. (Figs. 2-3.) Here, the stage of development of all the teeth

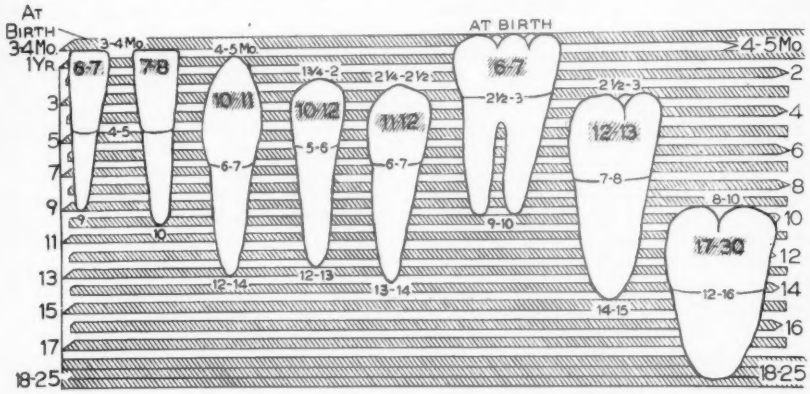

Fig. 2.—Another type of graph of upper set of permanent teeth. This has the advantage of showing at a glance the size of each tooth developed at specific ages. The teeth cannot be drawn in correct anatomic form as the growth lines are depicted parallel to each other. Shaded figures indicate the time of eruption of the teeth.

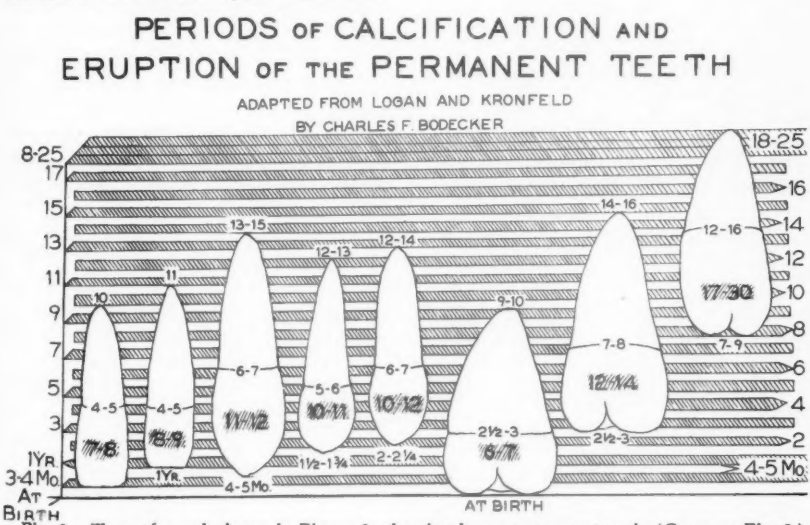

Fig. 3.—Type of graph shown in Figure 2; showing lower permanent teeth. (Compare Fig. 2.)

can be seen at a glance for any particular age. Should enamel hypoplasia or mottled enamel be noted on the teeth of a patient, the dentist can define readily at which age the child suffered from some exanthematous disease or lived in a district in which the drinking water contained an excess of fluorine.

The disadvantage of the type of graph shown in Figures 2 and 3 is that the anatomic relationship of root to crown cannot be shown correctly. Generally speaking, the roots of teeth are more than twice as long as the crowns; whereas, in the chart, most of them are depicted as being of equal length. This is due to the fact that the time required for the development of the crown and of the root is approximately the same; hence, they must be drawn in the chart as having an equal length. To take the example of the lower central incisor: the chart shows that the crown is developed in three and three-quarters to four and three-quarters years while the root is completed in from four to five years. These spans of time are almost equal; hence, crown and root are shown of approximately equal length in the chart.

One possibility was tried to approach a better anatomic relationship: the spaces between the age lines of 5 to 9 years were doubled and this procedure achieved our purpose for the incisors, but distorted the crowns of the other teeth. An examination of the chart shows that the age lines of 5 to 7 pass through the crowns instead of the roots of the cuspid, bicuspids and second molar, thus lengthening the former unduly. There seems, therefore, to be no method of showing the correct anatomic forms of all the teeth by widening the spaces between the growth lines. Consequently, we have come to the conclusion that, in spite of the disadvantage of incorrect anatomic forms of the teeth, it seems that the charts shown in Figures 2 and 3 are the more useful of the types of graphs for clinical purposes.

The principal exceptions to the statement that roots develop twice as fast as the crowns of the teeth are the first molars. The crowns of these teeth develop very rapidly, that is, in two and one-half to three years. The crowns of the upper lateral incisors likewise develop more rapidly than the remaining teeth. These observations, which were brought to our attention in making the graphs, may throw some light on the high caries incidence of these teeth.

Charts on the calcification and eruption of the deciduous teeth are being prepared and will also show the average age at which the resorption of their roots begins.

Every one interested in the teaching and practice of dentistry, as also research workers in dentistry and medicine, should become conversant with these recent studies. They render the previous tables of calcification and development of the teeth obsolete.

A DISCUSSION OF THE ACTION OF DR. HARTMAN'S SOLUTION*

By THOMAS J. HILL, D.D.S., Cleveland, Ohio

THE recent publicity relative to a desensitizing fluid made public by Dr. Hartman[1] has been given very wide attention. There should be some discussion of this material from a discriminating point of view. Various desensitizing fluids have been suggested in the past, but because of the failures that have always attended the use of all such solutions, dissatisfaction and discontinuance of their use have resulted. Pain is a subjective symptom and clinical comparison of the reduction of pain is very difficult, but that the transmission of sensation can be reduced by the use of Dr. Hartman's solution is the experience of most operators. In those cases in which failure results, and we cannot understand why, there is dissatisfaction. Dr. Hartman has attempted to explain the failures occurring with the use of his solution as due to improper technic and failure to use solutions that were properly balanced.

The theory is advanced that the lipoids within the dental tubules play some part in the transmission of sensation, and that this solution, because it is a solvent of and is dissolved in lipoids, in some way changes the ability of the lipoids to transmit sensation. This explanation is not entirely satisfactory. At the present time, we do not understand the manner in which such solutions affect the transmission of sensation. The work of Weber[2] and Euler and Meyer[3] has shown the presence of lipoids within dental tubules beneath the area of dental

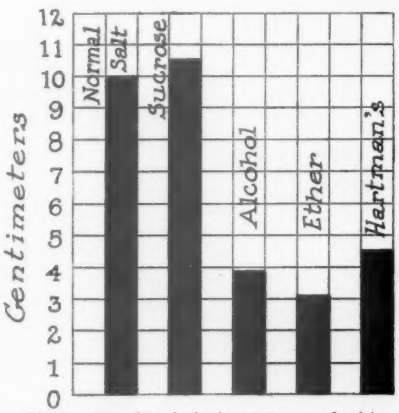

Fig. 1.—Results of placing 0.5 mm. of tubing with one end in normal salt solution; effect of surface tension on capillary attraction. *1*, normal salt, capillary attraction 10 cm. *2*, drop of 45 per cent sucrose solution in top of tube increasing surface tension, capillary attraction 10.5 cm. *3*, drop of alcohol in top of tube, surface tension reduced, capillary attraction 3.8 cm. *4*, drop of ether in top of tube, surface tension reduced, capillary attraction 3.1 cm. *5*, drop of Dr. Hartman's solution in top of tube, surface tension reduced, capillary attraction 4.5 cm.

*From the Institute of Pathology and School of Dentistry Western Reserve University.

1. Hartman, L. L.: New and Effective Means for Dentin Desensitization. New York J. Dent., 6:39 (Jan.) 1936.

2. Weber, R.: Zur Kenntnis des Auftretens von Fett am Zahn, Vierteljarsschr. f. Zahnheilk., 32:64, 1926.

3. Euler, H., and Meyer, W.: Pathohistologie der Zahn, Munich: Bergman, 1937.

caries and in the region of the dentin adjacent to the odontoblastic layer; that is, in predentin. The lipoids in the predentin region are found in normal teeth. The lipoids found beneath dental caries are pulpwise from the transparent zone of dental caries and not immediately beneath the carious area. It is probable that they might be related to a degenerative process within the fibril and they may possibly play some part in intratubular calcification. It has not been shown that lipoids are in any way associated with the transmission of sensation through the dentin.

Dr. Hartman's solution, which is composed of approximately 50 per cent ether, is not readily miscible with water. Any marked penetration of the tubules containing moisture would not be expected from such a solution. When finely divided carbon particles are added to Dr. Hartman's solution, its penetration of dental tubules can be traced for only 40 to 50 microns (0.05 mm.).

Ferric chloride was added to Dr. Hartman's desensitizer and the teeth were treated as prescribed. They were then immersed in potassium ferrocyanide. The resultant action was to convert the free iron into a ferroferric cyanide (Prussian blue). The teeth were then sectioned. (Figs. 2-3.) It will be noted that the penetration does not exceed 0.05 mm. and does not reach the region where lipoids are demonstrable.

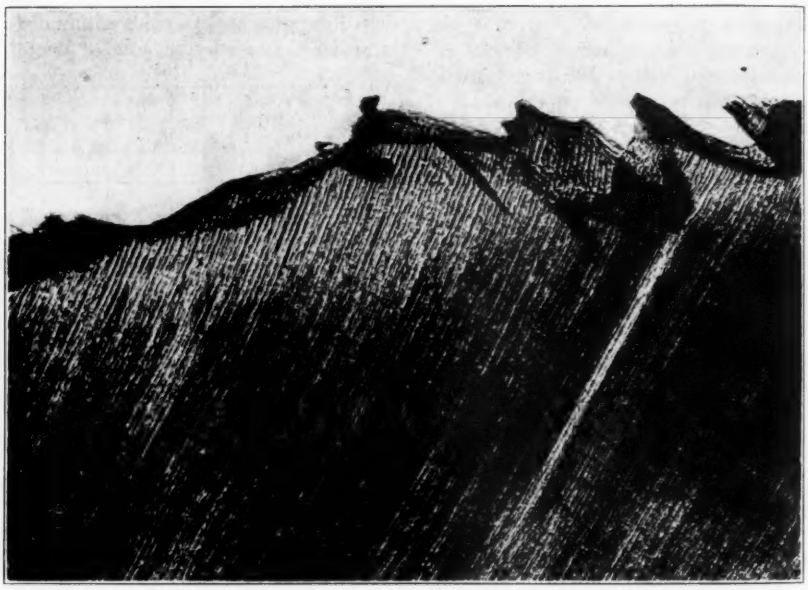

Fig. 2.—Cross-section of teeth treated with Dr. Hartman's solution to which ferric chloride was added. The teeth were then placed in potassium ferrocyanide and free iron converted to ferroferric cyanide (Prussian blue). The depth of penetration is evident. (×130.)

Prinz[4] and Wannach,[5] who have advanced the theory that the transmission of sensation through tubules is a physical phenomenon, believe that increased sensitivity of dentin is associated with increased surface tension. They believe that the fibril acts as a colloidal membrane and, when the external part becomes exposed to fluids with increased surface tension, hydrostatic pressure is created within the tubule by its absorption of fluid from the pulp, and the more nearly solid column of water more readily transmits sensation. This is the most plausible explanation as to why dentin is sensitive on exposure to sugars. Figure 1 shows the results of capillary tubing, which represents dental tubules with one end immersed in a normal salt solution representing dental pulp. When the atomic weight of a fluid is taken into consideration, the capillary attraction is dependent on its surface tension. The first tube shows the normal capillary attraction of the salt solution. In the top of the second tube, a drop of sucrose solution was placed. The surface tension is increased and more fluid is drawn into the tube. In the top of the second tube was placed a drop of alcohol, which has a surface tension (room temperature, 22 degrees; density, 0.806) of 24 dynes per

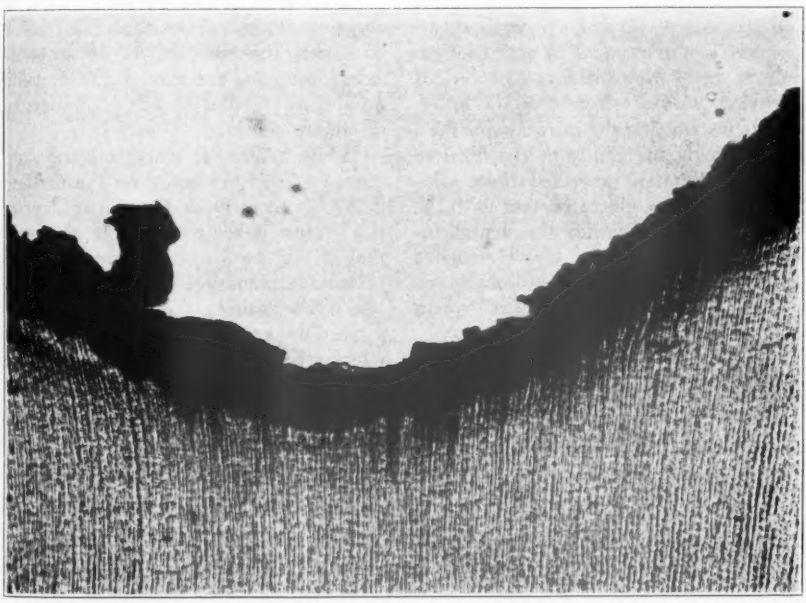

Fig. 3.—Cross-section of teeth treated with Dr. Hartman's solution to which ferric chloride was added. The teeth were then placed in potassium ferrocyanide and free iron converted to ferroferric cyanide (Prussian blue). The depth of penetration is evident. (×130.)

4. Prinz, Hermann: Diseases of Soft Structures of Teeth and Their Treatment. Philadelphia: Lea and Febiger, 1928.

5. Wannach, William: Hypersensitive Dentin, Zahntech. Ref., 24:47 (Nov. 21), 1920; abstr. Internat. J. Orthodon., 7:459 (Sept.) 1921.

centimeter in comparison to the salt solution, which has a tension of 73 dynes per centimeter. The surface tension is reduced and fluid is expelled from the tube. In the third tube was placed a drop of ether, which has a surface tension of 16 dynes per centimeter. In the fourth tube was placed Dr. Hartman's solution, which has a surface tension of 26.3 dynes per centimeter, which is higher than that of ether or alcohol, but because of the increase in molecular weight, owing to the presence of thymol, its capillary attraction is nearly equal to that of alcohol. It seems probable that all solutions with low surface tension would be effective in reducing the intratubular fluid and reducing the ability of the fibril to transmit sensation provided these solutions can be brought in contact with the vital protoplasm within the dental tubules. If the action of Dr. Hartman's solution depended on the solubility of lipoids, it would be difficult to explain why sensation returns after the cavity has become moist from saliva, but this can be explained on the basis of surface tension. Various solutions advocated in the past, such as benzyl alcohol, 5 parts, chloroform, 3 parts, and alcohol, 2 parts (Kudler)[6]; absolute alcohol, and eugenol owe their efficiency to reduction in surface tension, refrigerant action and dehydration. It is recognized that thymol is a local anesthetic, but because of the failure of penetration to any considerable depth, its function is difficult to understand. It should be expected that the efficiency of any such solution would be markedly impaired by the physical condition present beneath caries, such as clogging of the tubules with the residue of caries, the presence of intratubular calcification and the reduction in size and number of tubules by the formation of secondary dentin.

While additional work is being conducted at this university on the method by which these fluids desensitize dentin, this review is being offered in the hope that it may be a contribution toward a rational explanation of the method by which desensitizing fluids operate and as a possible explanation of the failures which attend such procedures.

6. Kudler, G. D.: Hypersensitive Dentin: Character and Treatment, D. Cosmos, 75:488 (May) 1933.

The Journal of the American Dental Association

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C. N. JOHNSON, Editor

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All expressions of opinions and all statements of supposed facts are published on the authority of the writer over whose signature they appear, and are not to be regarded as expressing the views of the American Dental Association, unless such statements or opinions have been adopted by the Association.

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Editorials

THE 1936 MEETING OF THE AMERICAN DENTAL ASSOCIATION

The limited time between the New Orleans meeting in November and the coming meeting in San Francisco makes it necessary for the most intense application on the part of those who are charged with its preparation if we are to witness a standard performance. And the performance must be standard for us to maintain anything like a steady pace of progress. It must never be said that a given meeting of the American Dental Association shall ever be held that is less in importance than any previous meeting, and so the coming meeting must measure up to the best traditions of the more or less exacting past.

To accomplish this, an unusual amount of work must be done in addition to what has already been achieved. Fortunately, the spirit of the West Coast, as represented by the profession of San Francisco, Oakland and vicinity, may always be counted on for a major performance whenever it comes to staging a large meeting, and the Local Committee on Arrangements has gone resolutely

at its work, with a determination to provide the best means possible for the accommodation of the members and guests.

But the most essential thing in every successful meeting must manifestly be the character of the program, and the problem of providing an outstanding program for the coming meeting must constitute the first big hurdle for our officers and committeemen. The officers may always be trusted to provide adequate entertainment for the general meetings, and it remains for the chairmen of the Sections to furnish us with outstanding men for essayists in the various departments of our service. This means that each chairman should select his speakers on the basis of their ability to present the subject, and not on the basis of good fellowship alone.

After all, it is the quality of the material that is presented at the meetings and published in our official organ that makes or detracts from the reputation of the Association, and this should be considered at the fountainhead, which means in the selection of our essayists.

Without question, there is an undoubted appeal in the prospect of going to the West Coast for this meeting. San Francisco is always interesting, with an attraction all its own. No other city is quite like it and it has always been known as the most cosmopolitan of all American cities. From the glamorous days of the forty-niners, the atmosphere of adventure has never ceased to intrigue the visitor, and this tradition has been carried on through each succeeding generation till San Francisco is known not only from coast to coast but to the uttermost confines of our entire country.

With the present setting and the culmination of one of the greatest engineering projects ever undertaken in the form of the two great bridges, the Golden Gate and the Bay bridges, visitors to the 1936 meeting will be presented with a spectacle the like of which they have never before beheld.

The trip from the eastern, southern or middle states is filled with scenic beauty no matter what route is taken, and there is a likelihood that special reduced rates may be granted beyond the usual summer reduction. In case this becomes effective, announcement will be promptly made.

At the time of the meeting, a portion of the U. S. Battleship

Fleet will be stationed at San Francisco, and this will be an added attraction.

Another important feature of the meeting tending to the comfort of the visitors is the fact that during July the weather of San Francisco is usually fine.

One thing more should be stressed in connection with this meeting, and it involves a question of loyalty. Through the years that are past and the meetings that have been held in different sections of the country, it has uniformly been the case that the men of the West Coast have been more faithful in attendance than have the men of any other section of the country a similar distance from the meeting place. They have journeyed east at a great sacrifice with unerring faithfulness, and now that the meeting has been brought to their doors, it is only fitting that the rest of the country should cordially reciprocate by journeying to the Coast.

A cordial welcome awaits the members of the other sections of the country. California may always be counted on to provide entertainment of a unique and pleasing character, and all they ask is the privilege of being made host.

A CERTAIN AMOUNT OF MUCK-RAKING

Sometimes it would seem that a certain amount of muck-raking is necessary, its sole value being to prevent us from becoming too complacent and smug. Smugness may easily become fatal if carried too far, and a little stirring of the dry bones may be salutary.

But muck-raking that consists solely of raking muck does no one any good, and it lends itself to destructiveness, pure and simple. No stable or solid structure was ever built by the process of muck-raking, no incentive was ever thereby had for the ennobling or inspirational virtues of life. Little that is constructive in the affairs of men ever resulted from the petty persecution of constantly complaining of things as they are, and little good is done by pettishly slamming a damper on the glow of life.

These observations are brought out by reading a book "The Patient's Dilemma" by S. A. Tannenbaum, M.D., and Paul

Maerker Branden, with the subhead "A Public Trial of the Medical Profession." When the request came from the Committee on Dental Economics that we deal with this book editorially, we confess to a very definite reservation. This for two reasons: It was felt that the medical profession was amply able to take care of itself against such attacks, and then there is always the inevitable feeling that to notice a book of this kind, even in a derogatory way, is merely to advertise it. But the consensus of opinion seemed to argue for a word to be said on the subject.

The book is a more or less subtle arraignment of the medical profession from beginning to end. It opens with reflections on the prevalent tendencies of the day toward the widespread employment of specialties as against the old line practice of general medicine, with all of the evils consequent on the change. There is just enough of self-evident truth in the contentions to make them seem plausible, until the reader wakens to the fact that the argument is manifestly one sided and altogether unfair. The distortion of a truth may easily become so great as to constitute itself practically a falsehood, and, in this instance, the evils of specialization have been played on to bring out all of the ills without the slightest disposition to present the compensations.

With our present complex set-up in modern life, a certain amount of specialization in the professions is not only justifiable but absolutely inevitable if some of the intricacies of disease are to be met and successfully treated. Why then cast a reflection on all specialties merely because in some cases specialization has been carried too far? Why, unless to indulge in the propensity for raking muck?

All through this book, the seamy side of medical practice has been magnified to the almost utter exclusion of everything that is legitimate and wholesome in professional life. If the rank and file of medical practitioners were a body of men and women devoid of principle and wholly committed to the nefarious practices of exploiting the people, there might have been some justification for writing this book, but let us change our vision for a moment and turn our attention to the history of medicine with its best traditions, its ethical standards and its widespread service to

humanity. What other profession can quite measure up to it?

Wipe medicine out of our civilization and there would be little of civilization left. Wherever humanity has suffered from physical ills—and physical suffering has been well nigh universal—medicine has come resolutely to the rescue and has devoted its best energies to the alleviation of human disability. Its members have sacrificed their comfort, their convenience and their lives to its service. Its literature has been enriched by the noblest concepts of devotion and self-abnegation, and it has laid on the altar of human service the largest wreaths in the category of all the callings.

How insignificant then in the face of all of this is the distorted doctrine taught in the book under consideration. How essentially silly is the attempt to thrust a javelin in the few breaches in the armor of organized medicine with the hope that through some fluke a vital spot may be reached.

But in the latter part of the book the whole thing comes glowingly into the limelight, and we are regaled at last with the panacea that has been in the minds of the authors, from the beginning of their case. (We knew there must be a panacea.) All of the medical ills enumerated in the book, in fact most of the ills of humanity at large, are to be cured in one full swoop through the beneficent agency of *socialized medicine.* Now we have it! The cat is out of the bag. Why did not the authors in the beginning give us some small hint of what they had up their sleeve, and save us the trouble of wading through such a vast and smelly accumulation of muck?

THE NINTH INTERNATIONAL DENTAL CONGRESS

On August 2-8, 1936, in the city of Vienna will be held the Ninth Congress of the Fédération Dentaire Internationale. Extensive preparations are being made for this event. A comprehensive set of rules has been drawn up for the guidance of prospective members, the details of which need not be elaborated here.

The proceedings will consist of general sessions, section meet-

ings and demonstrations. The Congress will comprise fifteen sections. Three sections, each covering quite different fields, will meet at the same time in three different rooms. The working program of the Congress will thus be completed in five days.

The official languages of the Congress will be English, French, German (all three obligatory) and Spanish or Italian as the reporter may choose. Other languages may be used with the consent of the presiding officer.

The first general session will be opened by the president of the International Dental Federation, who shall induct the president and officers of the Congress.

At the closing session, the date and place of meeting of the next International Dental Congress will be determined.

The sections are as follows: 1. Anatomy, Histology, Physiology, Pathology. 2. Full Denture Prosthesis. 3. History of Dentistry, Documentation, Professional Press. 4. Cause and Treatment of Dental Caries, Fillings. 5. Crowns, Fixed Bridgework, Ceramics (Porcelain). 6. Education. 7. Anesthetics, Narcosis, Radiology. 8. Periodontal Diseases. 9. Public Health Service, Social Legislation. 10. Root Canal Treatment, Focal Infections. 11. Partial Removable Denture. 12. Metallurgy. 13. Oral Surgery. 14. Orthodontics. 15. Physics, Chemistry.

An innovation of this Congress will be a device to enable the visitors to hear the reading of papers or reports in any one of the official languages of the Congress. The papers will be translated at the same time that they are being read and sent over a microphone to a transmitter to which headphones are attached. By adjustment of the headphones, the member can choose the language with which he is most familiar, thus making it possible to follow the reading of any paper in which he is particularly interested, or the description of any illustration that may be thrown upon the screen.

Appointment of State Advisory Committees

Since one of the major duties of the Fédération Dentaire Internationale Committee of the American Dental Association is to assist in the organization of each succeeding international dental

congress, the following information and recommendations are presented.

It is the opinion of your Committee that such plans should be adopted as would seem to be most certain of securing the attendance of a representative number of our members at this Congress; also, that our leaders should embrace the opportunity of appearing on the official program not only for the reason that the opinions of our outstanding men should be made available to other nationales, but they should be present to profit by the contributions to be made by the recognized authorities of all nations. Any worthy plan should provide that a fair distribution of these honors be allotted to the various states, and that such representation should include all sections rather than be confined to a few centers.

In order that such a desirable program may be consummated, it is recommended that state advisory committees be appointed, their membership to be as follows:

1. The expresidents of each state dental society for the years of 1932, 1933, 1934 and 1935, and the president who is to preside at the annual meeting for the year of 1936. (In such states as have provision for the office of president elect, the one who is installed in the year of 1937 shall also be made a member of the state advisory committee.)
2. The secretary of each state dental society who officiates at the state annual session for 1936. (The president and secretary presiding in 1936 shall automatically be designated as the chairman and secretary of each state advisory committee.)
3. The president, president elect, secretary and board of trustees of the American Dental Association.*
4. The president, president elect, or vice president and secretary of the National Association of Dental Examiners.*
5. The president, president elect, and secretary of the American Association of Dental Schools.*
6. The deans of the dental schools.*
7. Editors of dental journals.*
8. The president, president elect (if there be such) and secretary of any component of a state society that has a membership of 1,000 or over.

The duties of the state advisory committees shall consist (1) in securing members for the Congress; and (2) in aiding the Fédération Dentaire Internationale Committee of the American Dental Association in the selection of clinicians to represent their respective states.

It is recommended that authority be granted the president, president elect and secretary to present the names of ten members of the A.D.A. to the President of the United States for appointment as government officials delegates to the Ninth International Dental Congress, should such a request be received from the proper authorities in Vienna and Washington.

It is further recommended that the president, president elect and secretary of each state advisory committee be authorized to appoint three delegates from the membership of his respective state dental society as state delegates to the Ninth International Dental Congress; and like authority to be given to the president of such

*Provided any of said group reside in the state in question.

component societies of state organizations having a membership of 100 or over, to appoint not to exceed three delegates to the Ninth International Dental Congress.

With this authority, the instruction is given that, in all instances, the respective presidents, presidents elect and secretaries shall to the best of their ability select delegates whom they have reason to believe will be in attendance at the Ninth International Dental Congress.

Membership in the Congress

Membership in the Ninth International Dental Congress will be, as it has been in the past, open only to those who belong to a recognized dental association. Therefore, before one can be approved by the committee on membership, he must have his dues paid to the American Dental Association for the year in which application is made for membership in the Congress.

The membership fee is 70 Austrian schillings ($13.30).

Members of the Fédération Dentaire Internationale of not less than three years' standing, and whose subscriptions are not in arrears, shall be admitted to full active membership in the Congress without further payment except that the treasury of the Fédération Dentaire Internationale shall pay a sum equal to half of the Congress fee.

The membership fee, accompanied by the application form properly filled out, should be forwarded to the Secretary of the American Dental Association, Dr. Harry B. Pinney, 212 E. Superior Street, Chicago, who will certify as to the eligibility of the applicant and take the necessary steps to have the membership fee forwarded to the treasurer of the Ninth International Dental Congress.

It is therefore recommended that the Secretary of the American Dental Association be authorized to have application forms printed for membership in the Ninth International Dental Congress, and that those in charge of The Journal of the American Dental Association be authorized to give such publicity to the Congress as in their opinion would seem to be suitable for the promotion of the best interests of the American Dental Association in connection with the development of plans that pertain to the forthcoming Congress.

Everything is being done by our European colleagues, particularly in Austria, to bring this great meeting to a successful issue. Vienna is famed for science and art, and thus the atmosphere will be perfect for a great demonstration of the latest and best in dental science. The dentists of Vienna have pledged themselves to do all in their power to extend a most hearty welcome to members of the profession from other cities and other lands, and thus the visitors to the Congress may be assured of a hearty welcome, and of ample entertainment after their arrival.

The prospect for a large attendance from the United States and Canada is very gratifying. In addition to those going from this country, a large group is being organized in Canada to proceed by ship through the St. Lawrence River and by a short route to

Europe in time for the Congress. Thus will be presented an opportunity to visit at a nominal expense not only the Congress itself but also some of the most historic spots of Europe. We urge our confrères on this side of the water to begin making preparations at once for this great event. In no other way can the dentists of America so surely avail themselves of an opportunity to refresh their minds on the latest and best in dental progress, and at the same time enjoy a most restful and attractive vacation.

Remember—Vienna, August 2-8, 1936, the Ninth International Dental Congress.

THE AMERICAN DENTAL FOUNDATION INCORPORATED

In the March, 1933, issue of THE JOURNAL, an editorial was published announcing the formation of the American Dental Foundation Incorporated. At that time, the profession was urged to bear the matter in mind with the idea that some of the members might find it in their hearts to make a provision in their wills for a donation to this cause.

Dr. Edward H. Bruening, who was then one of the Trustees of the A.D.A., was the leading spirit in advancing this very worthy cause, and we wish to call attention to the matter once more.

We ask that the editorial be read again, in the belief that it contains something of interest to every member of our Association.

PRACTICE IN PARAGRAPHS

This department is intended for busy readers. It aims to tell a vivid story in a few words. Items should be of a practical character, and free from padding—not more than a paragraph or two. We exact no limit, but two hundred words can tell most of these stories. Send in your ideas; they will be welcome.

Backing for Steel Facing—To make a backing for a steel facing, smear the back with glycerine. Take a sheet of pink baseplate wax and insert edgewise in the slot. Flow blue casting wax over the entire surface of that facing. Remove and it is ready for casting.—*C. C. Norris, Oshkosh, Wis.*

Silver Nitrate Remover—Too often a small drop of silver nitrate will find its way to a patient's lips or face, to be discovered at the following appointment. A pellet of cotton saturated with a saturated solution of potassium iodide will remove the stain with only a minimum of effort, and if followed by water will leave no blister and no stain. This will also work on cloth before washing.—*E. E. Harris, Austin, Texas.*

Inlay Technic—In some operators' hands, the effort to conserve dentin in cavity preparation for large inlays places the gold too close to the dentino-enamel junction, constant discomfort resulting. Roentgen-ray examination shows the tooth to be normal as far as the pulp is concerned and one wonders what is wrong. If the inlay is removed and the cavity prepared to the usual depth of 1.5 mm. the trouble will be corrected.—*Harry A. Tuckey, 450 Sutter St., San Francisco, Calif.*

Breaking Clasps—In my years of experience, I have had annoyances with clasps breaking, and I venture the opinion that anybody who has not had that annoyance has had a limited experience with that type of restoration. These breaks usually take place where the solder has rendered the clasp metal hard and brittle. This annoyance can be reduced considerably by making the lingual and labial or buccal parts separately with about one half inch extensions, which serve as lugs. If the extreme ends of the extensions are soldered, the solder does not get on the spring part of the clasp. —*C. A. Hintz, New Ulm, Minn.*

Organization Vs. Indifference—One's imagination falters in efforts at solving the indifference of a host of dentists to organized dentistry. To any constructive dental activities, they seem absolutely immune. Outside their offices means outside dentistry. They reap much and sow little. Their professional daily bread is being buttered *for* them and their families by loyal devotees to a purpose. They enjoy the choice fruits ripened by other men, who believe that contribution to organized dentistry is a duty to mankind. Dr. Ruska, of Temple University, wisely states that "organized dentistry is the greatest dental college on earth." Much latent ability lies in the army of "hold out," "organizationless" dentists. And local societies should make greater effort to gather them into the fold.—*Herbert Ely Williams, Red Bank, N. J.*

Cleaning Vs. Filling—Cleaning sounds more musical to the ear of the grade-school patient than drilling with the bur. The term "cleaning," removing decayed dentin, is a nicer word in reality and more effective psychologically than such words as "drilling" and "filling." To inspire confidence, children's teeth should always be brushed first, the operator shifting to a cavity, if possible, without their knowledge or concern. Preparation for filling carried out under the ruse of cleaning carries far less mental pain, physical apprehension or traditional fear. That it is done under the head of "cleaning" lessens in no way the effectiveness of what has been done. What is there in a name or a word anyway? With work well performed, "how you did it" is completely outranked in importance by "have you done it?"—*Herbert Ely Williams, Red Bank, N. J.*

COUNCIL ON DENTAL THERAPEUTICS

P. T. M. FORMULA COMPANY BARRED FROM MAILS

A report on P. T. M., a pyorrhea nostrum which was sold through the mails appeared in THE JOURNAL, August, 1935, pages 1395-1397.

The report pointed out that, at the time the product was being advertised in *Dental Survey*, it was held not acceptable by the Council and reference was made to its seizure by the United States Department of Agriculture for violation of the Food and Drugs Act of 1906. Since that time, an investigation of the Post Office Department has been completed and a postal fraud order was issued against the P. T. M. Products, Inc., P. T. M. Formula Co.; and their officers and agents as such at Los Angeles, Calif. Following is a summary by the National Better Business Bureau, Inc., of the fraud order issued:

On January 27, 1936, a postal fraud order was issued against P. T. M. Products, Inc., P. T. M. Formula Co.; and their officers and agents as such at Los Angeles, California. This advertiser was the subject of a bulletin issued by the Bureau on January 30, 1935.

The company has been engaged in the sale of an alleged cure for pyorrhea and trench mouth since March, 1933. The business was organized by Jackson Diggs who continued as president after its incorporation. Advertisements were placed in periodicals through the agency of Logan & Stebbins headed: "Heals Pyorrhea, Trench Mouth for Thousands" and throughout the original copy and follow-up literature claims were made that through use of the "treatment" pyorrhea and trench mouth would be eliminated, stopped, cured, and that the teeth and gums would be restored to normal and other representations equivalent to claiming a cure.

The P. T. M. Formula was also repeatedly described as a "home treatment." Actually after spending their money, the would-be-home-treaters were told that they must go to a dentist to have their teeth thoroughly cleaned and deep-scaled with all tartarous deposits completely removed before using the "home treatment." Such a description, the Solicitor for the Post Office accordingly found, was false and fraudulent.

The claims regarding the curative properties of the treatment were found to be equally false. Expert witnesses for the government testified that only proper instrumentation at the hands of a competent dental surgeon could eliminate pyorrhea by removal of the tartarous deposits, diseased bone tissues and other concomitants of the disease. The P. T. M. Formula was declared to be worthless for that purpose. Further expert testimony was adduced to show that not only would the so-called home treatment fail to cure trench mouth, but might, on the contrary, prove injurious in the treatment of that disease.

In summary, the Solicitor made the following finding:

Respondents' periodical advertisements, circular letter and folders contain false and fraudulent representations to the effect:

(a) That the P. T. M. Formula is a "home treatment";

(b) That it will speedily and permanently cure pyorrhea, trench mouth, and sore, tender and bleeding gums;

(c) That it may be safely used by anyone in the elimination of these conditions;

(d) That it is a thoroughly tested and approved dental remedy for the above named diseases of the mouth.

The fraud order was accordingly issued.

The question may be raised, "Is it not worthwhile to insist on Council acceptance before advertising in dental journals is accepted?"

DECROSAN AND PYRO-SANA—NOT ACCEPTABLE FOR A. D. R.

The Council has authorized publication of the following report.

SAMUEL M. GORDON, *Secretary.*

Decrosan was submitted to the Council by the Pyro-Sana Laboratories, St. Louis, Mo. It is stated to be a mixture of "35% modified creosote in a glycerin base." As the special properties claimed for Decrosan appear to rest on modified creosote, the firm was requested to inform the Council of the manner in which "modified" creosote differs from the form recognized in the U. S. Pharmacopeia. The firm replied:

> After some 10 years of effort, he (the writer) secured the cooperation of Merck & Co., who now make as good a creosote as one can find.

Merck & Company market creosote, U.S.P., and it is listed in A.D.R. The firm further states:

> The difference between raw creosote and that modified by us is in the taming of the acid phenols.

How this is done, or how Beechwood Creosote, U.S.P. X is modified by such treatment is not known, and certainly the "taming" of acid phenols is a procedure yet unknown to chemistry and pharmacy.

Thus, for all practical purposes, one is justified in concluding from the statements of the firm that Decrosan is essentially a 35 per cent solution of creosote in glycerin. No evidence has been submitted by the firm that Decrosan with its "tamed" acid phenol will do more than such a solution of creosote in glycerin. A statement of composition as required by Rule 1 does not appear on the label. The presence of a potentially poisonous substance is also not declared as required by Rule 7, and the Council cannot accept a proprietary name, Decrosan, for a simple mixture of readily available substances. The use of creosote or guaiacol diluted with glycerin in dentistry or oral surgery is not new. This was discussed in the report of the Council on Stopain.[1]

In view of the foregoing, it is difficult to agree to the statements on the carton that Decrosan is a "Balanced Germicidal-Granular Stimulant Anaesthetic." What is meant by "balanced" is not readily apparent. That such a solution possesses germicidal and anesthetic properties may be granted. It does this not by any virtues present in the mixture of Decrosan as such, but because of the phenols present. The claim that Decrosan is "A Hemostatic Astringent Neutral Antacid" is more than can be granted for a solution of creosote in glycerin, for creosote is not generally recognized as a hemostatic or an antacid preparation. Chemically, phenols have slightly acid properties.

In view of the foregoing, it is not necessary to discuss in detail the claims of Decrosan for use in sockets after extraction, for dry sockets, pus pockets, putrescent canals, abscessed conditions, Vincent's infection and other gum and mouth inflammations, further than to point out that the use of beechwood creosote in Vincent's infection and mouth inflammations is not in line with conservative dentistry. The attempt to widen the uses of creosote for "other gum and mouth inflammations" cannot be condoned, since it is well established that certain lesions of the mouth are beyond alleviation or cure by medicinal agents, in which case surgical intervention or other methods of therapy are required. Thus, it is seen that the claims for Decrosan are unwarranted and exaggerated.

Pyro-Sana is, according to the firm, "approximately 2% modified beechwood creosote, sugar sufficient to make acceptable to taste, water QS." It is advertised in conjunction with Decrosan, and its use is part of the Decrosan Treatment, since it is asserted that its

1. J.A.D.A., 21:2220 (Dec.) 1934.

use prevents reinfection, keeps pain allayed and stimulates granulation. Pyro-Sana is intended for direct use by the patient, either with or without the advice of the dentist.

On the label appears: "For Gums Mouth Nose Throat." While this appears to be innocuous and general, it can be no more countenanced than if specified diseases were named. The Council continues to raise the question as to how the user of Pyro-Sana, or any similar preparation, is to recognize the difference between those forms of gum manifestations that disappear without medication and those that require careful treatment by skilled practitioners, such as noma and cancer or stomatitis medicamentosa. In its use as a mouth wash, it is subject to the same limitations as are all mouth washes.

Pyro-Sana was the subject of a notice of judgment for violation of the Food and Drugs Act in December, 1933. A statement of composition does not appear on the label, nor does a statement of the presence of a potentially poisonous substance, creosote, appear thereon. The firm is not entitled to a proprietary name for a simple aqueous solution of readily available material.

In view of the foregoing, Decrosan and Pyro-Sana are declared inadmissible to A.D.R.

FEED-'EM—NOT ACCEPTABLE FOR A.D.R.

The Council has authorized publication of the following report.

SAMUEL M. GORDON, *Secretary.*

Feed-'Em was submitted to the Council by the Feed-'Em Company, Richmond Hill, N. Y., with the statement that this was done in conformity with a wish of the New York City Department of Health before it was to be placed on the market in this country. Feed-'Em is manufactured in Germany by the Homoia-Gesellschaft, Karlsruhe, and is supplied in tablets for internal administration. The firm was requested to submit a statement of the quantitative composition of the product and of assays for vitamins A, C and D.

The composition of Feed-'Em is claimed to be a "calcium-phosphor preparation containing fluorcalcium, lecithin and vitamins A, C and D." It is said to be prepared from cow's milk and not to contain any drug or harmful ingredient. In reply to the request for the quantitative composition and vitamin assays, the firm submitted only a report embodying results of "biological tests with tooth-fluoride." There is no indication in the original application, or in this report, as to the exact quantities of the various constituents; nor is it clear which compounds of calcium, phosphorus and fluorine may be present.

The report on bio-assay tests for vitamins is lacking in a number of essentials; namely, concentrations and dosage of the product, ages, weights of rats used in the tests and actual results. It is not clear from the report whether the concentration of fluoride in Feed-'Em would be sufficient to affect the teeth, weight and growth of animals. If adult rats were employed in the tests, dental defects caused by the feeding of fluoride would not be revealed. For such purposes, young growing animals must be used. Instead of actual data and results in curves or tabulations, only summary statements are submitted. This makes it impossible to determine the validity of the claims. As far as the actual assays for the vitamins are concerned, the experiments are equally lacking in essential details, such as the number of animals used for each test, and therefore are practically meaningless. The results claimed to have been obtained may be entirely accidental and have nothing to do with the alleged beneficial effects of "tooth-fluoride." Even less critical are the experiments claimed to have been made on the germicidal power of blood

of animals given "tooth-fluoride." Apparently, the results with "tooth-fluoride" are intended to apply to the product to be marketed as Feed-'Em. Strangely contradictory are the following statements with reference to the action of fluoride:

> For a white and strong enamel the blood must contain a minute quantity of Fluorine, besides the other minerals, which is found in an easily assimilable form in Feed-'Em. . . . It (Feed-'Em) contains all elements for normal dentition and tooth function.

The contradiction is obvious from the fact that any whitening of the enamel would take place through a systemic poisoning action of the fluorine, which, of course, would not be desirable for normal dentition and tooth function. Other claims are equally ridiculous and untenable, such as that the product acts as a prophylactic in rickets and increases the body's power to resist infectious disease.

Therefore, Feed-'Em is declared unacceptable; i.e., because of conflict with Rule 1 (exact composition not revealed); Rule 6 (unwarranted therapeutic claims); Rule 8 (objectionable name) and Rule 10 (unscientific and useless article).

BUREAU OF PUBLIC RELATIONS

MOUTH HYGIENE IN KERN COUNTY, CALIFORNIA

By CLELLA McCULLOUGH,† Bakersfield, Calif.

KERN County is located in the central part of the State of California and makes up the southern part of the San Joaquin Valley, Sierra Nevada Mountains and Mojave Desert.

One dental hygienist is employed by the Kern County Board of Supervisors, to spread the message of mouth health to the children and parents living high up in the Sierras, far into the desert and throughout the valley. Let us visit the dental hygienist as she goes about her work in the county schools. We meet her at the County Garage in Bakersfield, and drive to the outskirts of the city, to the Kern General Hospital, where, in one wing, is located the health department offices. Here we meet Dr. Joe Smith, the health officer, Dr. Myrna Gifford, assistant health officer, Gwendolyn Devenish, supervisor of nurses and her four public health nurses, Mr. Clifford Baughman, sanitary inspector, Mr. Fred Lucas and Mr. O. H. Hindman, milk inspectors, Dr. J. H. Inman, director of the public health laboratory, and the office staff. These people make up the staff of workers employed to "guard" the health of Kern County.

We are given a copy of the annual report of the activities in the health department, and, turning over the pages, we read a report of the dental hygiene division. The following outline shows the mouth hygiene activities that have been "followed through" the past twelve months:

I. Dental examinations.
II. Class health talks.
    1. Proper foods.
    2. Visits to the dentist.
    3. Adequate home care.
III. Sells Health-O-Circus. An instructive and interesting health education program (secured from the American Dental Association), sponsored in eight communities.
IV. Silver trophies.
    Twenty-Thirty Club.
    Kern County Dental Society.
    Joe Smith, health officer.
    L. E. Ford, Dean of the College of Dentistry, University of Southern California, Los Angeles.
V. Dental hygiene talks.
    P. T. A. meetings.
    Service clubs.
VI. Dental hygiene exhibits.
    Southern California state dental meeting, Los Angeles.
    Kern County Teachers' Institute, Bakersfield.
    Pacific Coast Dental Conference, Long Beach.
VII. Two thousand sixteen toothbrushes sold at 10 cents each (furnished by the Kern County Tuberculosis Association).
VIII. Distribution.
    Dentistry and public health booklets.
    Dental leaflets.
    Toothbrush charts.

†Dental Hygienist.

IX. Moving pictures made. Dental hygienist at work. Sells Health-O-Circus, to be used with mouth health talks.
X. Dental health poster project.
Sponsored by the Kern County art supervisor.
XI. Follow-up work.
Teachers.
Public health nurses.
XII. Dental care given by:
Family dentist.
Kern County Dental Clinic.

While discussing this program with the dental hygienist, we learn that 9,571 children had their mouths examined and 4,574 mouths were found dentally fit. Seven hundred three individual conferences were held with principals and

Fig. 1.—Mickey Mouse button.

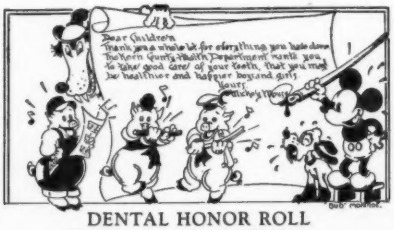
teachers, 175 parents visited the hygienist and 440 health talks were given.

The hygienist tells us about the Kern County dental bus and of course we are eager to visit the school where she plans to work. We leave the office, driving north through the valley, and passing the grape vineyards, where we see laborers busy picking grapes. As we drive on, we see the cotton fields, with their snowy white balls.

Our car is stopped in front of the beautiful grammar school at McFarland, Calif. Here, we meet the superintendent, who is very much interested in our visit. He takes a few minutes of his time to tell us "how enthusiastic the boys and girls are about having good teeth and taking proper care of them."

We are led to a large Dodge dental bus. The door is opened and we step inside. Here is a dental office as well equipped as one to be found in any city, being furnished with a large mahogany desk and chair, a lavatory with running water, a sterilizing unit and a dental chair and cabinet.

The mouth mirrors and explorers are



DENTAL HONOR ROLL

SCHOOL _____ GRADE _____

Fig. 2.—Dental honor roll.

all in place and records in order and the dental hygienist is ready to begin her day's work. During the few minutes that we are in the dental bus, a group of children flock about the door, asking, "Will you take our room first?" "When are you going to take our room?" These boys and girls are all eager to visit the dental hygienist. They want to know

whether they have good teeth, and if not, why. And what can they do about it?

School is called, and we are asked to visit a class room. While a mouth health talk is given to the children, a kindergarten class is visited. After "Good Morning" is said to the children, an instructive talk is given. The hygienist opens a large case and takes out a giant set of teeth and a giant toothbrush, which is used to show the children how to brush their teeth properly. The cavities or "brown holes" as they are called, are dissussed, and the children are told about the man who fills teeth, "the dentist." The thirty-five children are asked, "How many of you have visited the dentist with mother or father?" A boy raises his hand and he is asked to come to the hygienist, who shows the looking glass and pick (mirror and explorer), as she calls them, to the children, then examines his teeth, showing the nice silver fillings to the boys and girls. The boy tells how the dentist filled his teeth. This morning, all thirty-four children who had never been to the dentist are eager to sit in the dentist chair and have their teeth examined.

The hygienist has a short conference with the teacher and it is decided that she will go with the children. She wishes to know the condition of the mouths, as this will help her in following up the work of the hygienist. The children are lined up in front of the dental bus door and one by one have this delightful new experience, never to be forgotten.

Each child who has good teeth and uses his toothbrush is given a Mickey Mouse "Good Teeth Pin" to be worn to spread the good teeth message throughout the community.

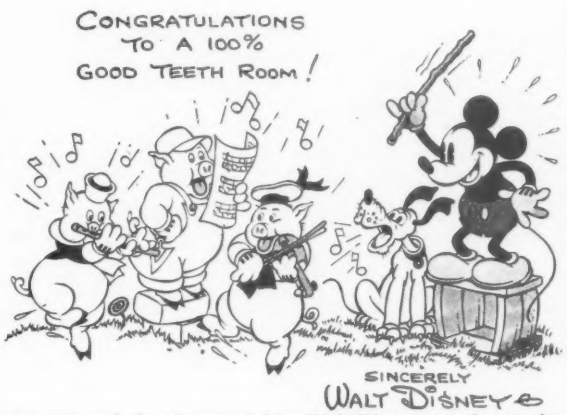


Fig. 3.—Picture autographed and presented by Walt Disney to each room having a 100 per cent dental honor roll.

For all children needing dental attention, the following notice is sent to the parents:

The teeth of_____have been examined and found to be in need of dental attention. BAD TEETH ARE A MENACE TO A CHILD'S HEALTH. YOU ARE URGED TO TAKE YOUR CHILD TO YOUR DENTIST and when all necessary work is completed, have your dentist sign this notice and give it to the child to Return to the Teacher.

Kern County Dental Hygienist.

To Whom It May Concern:

I have completed the necessary dental work for_____ and the teeth are in as good condition as possible at this time.

Date:_____

Dentist.

The hygienist explains: "When the parents have had the dentist care for the teeth, the child returns the dental notice to the teacher. On receipt of the good teeth note, the teacher places the child's name on the class room dental honor roll and presents him with a good teeth pin."

The dental honor roll is used by the teacher in following up the work of the hygienist. Each teacher is given a report of the mouth conditions in her room, and from the time the dental honor roll is presented to the class room until the end of the school term, a constant check-up is made by the teacher, who encourages all children to have their mouths put in good condition. Each class room that presents a 100 per cent dental honor roll to the Kern County Health Department receives a hand tinted picture of "Mickey Mouse and the Three Pigs," autographed and presented by Walt Disney.

The toothbrush chart saying
Mickey Mouse says Brush your Teeth
At least two times a day.
So I'm going to brush my teeth
And check my chart that way.

Fig. 4.—"Fields covered . . . with the beautiful golden California poppies, blue lupins and other wild flowers in endless variety. . . ."

and Mickey Mouse toothbrushes furnished by the Kern County Tuberculosis Association have helped thousands of boys and girls to establish the habit of brushing their teeth.

Dental truths are imparted to the children of different ages in such a way as to arouse in them an interest in their own teeth. Through the child's interest, that of the parents' is developed. When

a child's enthusiasm over good teeth has been aroused in the kindergarten age, we find results of our efforts throughout his eight years in grammar school.

One hundred and forty boys and girls return home from school that day with a determination to do just what the dental hygienist has told them.

Our next trip is on a warm day in March. We drive through recently developed oil fields and through fields covered like a blanket with the beautiful golden California poppies, blue lupins and other wild flowers in endless variety with their ever-changing colors. When we come to the foot of the Tehachapi mountains and look back over this vast valley, the poppies make the country look like a land of gold.

At the end of a 60-mile drive, which carried us over the Tehachapi mountains, we find ourselves in the great Mojave Desert. Here, we see vast stretches of desert, with bright colored patches of wild flowers and lonely Joshua palms, and high mountain ranges in the distance.

We stop at Saltdale, a small town situated on the edge of a dry salt lake bed, where we see huge blocks of salt being loaded on freight cars to be shipped to all parts of the country.

It is recess time at school when we arrive. The teacher and her eleven pupils rush out to greet the dental hygienist as she steps from the car. How happy they are to see her! For here in this small isolated place, few outsiders come to call. The dental hygienist makes a check-up to see how her instructions have been followed out during the school year, as she had made dental examinations of these boys and girls last November. She encourages them to visit their dentists again during their summer vacation when they take trips to the city, for they have no dentist practicing in the desert towns.

From Saltdale, we drive through Ghost City, a deserted town with here and there an adobe wall standing, the only remains of an early mining town. We drive through a gold gulch, where we see men out washing the sands for gold, and we stop to visit the Goler Gulch school. Many of these boys and girls have never had their teeth examined in school because their parents migrate from place to place in search of gold and do not remain in any one school district.

On our return, we pass the Dutch Cleanser Mines, the Petrified Forest and Red Rock Canyon. This canyon, with its cathedral-like formation, is a rendezvous of artists. We arrive at Mt. Owen School, the only log cabin school in the county. Here, the hygienist takes time, after finishing her mouth hygiene work, to look at dental health posters being made in the art class. Each child has worked out a cleverly designed poster, using Walt Disney's characters, Mickey Mouse, Minnie Mouse, Horse Collar, Donald Duck, Pluto and many other characters.

From here, we go to the Inyokern school. Here, boys and girls are all anxious to have us see their teeth. Many of the children are wearing the good teeth pins that they had won during the school year for having all dental corrections made. The dental hygienist collects the returned dental notes signed by the dentist and speaks encouragingly to the teachers and the pupils.

On our way back to Bakersfield, we drive through a pass in the Sierra Mountains until we reach the top of the Kern River Canyon. Here, we stop at a little town called Kernville, the center of mining activity and cattle raising and a favorite place for taking wild west movies. In the gold rush of the early fifties, it was known as Whiskey Flats.

As we drive down the Kern Canyon road, viewing all its rugged beauty, the hygienist tells us of many interesting experiences that she has had working among the Indians, Chinese, Japanese, French, Spanish and many other nationalities, and how fascinating she has found her work with these boy and girl crusaders for good teeth.

Leaving the dental hygienist in Bakersfield, our first comment is, "Every taxpayer in the county should visit the dental hygienist at work and see for himself what an educational mouth hygiene program is doing for the boys and girls in school."

These trips are only two of many interesting ones that could be taken with the dental hygienist as she travels throughout the county teaching mouth health in the eighty-four Kern County Schools.

The Preparedness League of American Dentists: After Twenty Years

By J. Wright Beach

The Preparedness League of American Dentists was founded in February, 1916 at Buffalo, N. Y., by Herbert A. Pullen, M. Burton Eshleman (both of whom are deceased) and J. Wright Beach, "to aid our Army Dental Corps by voluntary service of its members, who agree to prepare the mouth of at least one applicant to meet the requirements for enlistment, subject to such rules as shall protect the dentist from imposition."

Intensive activities of its nearly 20,000 members during the World War became the medium through which we were able to give material assistance to the government.

On February 12, 1936, in conjunction with the annual meeting of the Alumni Association of the Dental School of the University of Buffalo, the twentieth anniversary of the league was celebrated by a luncheon at which Weston A. Price was the guest speaker. Dr. Beach, president of the league, then read the following letter from President Roosevelt:

February 4, 1936.

The White House,
Washington.

My dear Doctor Beach:

It has come to my attention that you are celebrating the 20th Anniversary of the Preparedness League of American Dentists in Buffalo on February 12. I would like to take this opportunity to convey to you, the President, and through you to the officer and members, my sincere appreciation of the patriotic services by the dental profession through your organization.

The records of physical examinations for those entering the World War show that 27,015, or 1 per cent, of the total examined were rejected because of dental insufficiency. Undoubtedly, this number would have been greatly increased had it not been for the splendid and timely work of your organization. Your record of supplying adequate dental treatment to 500,000 service men at no cost to the Government is an achievement of which you may well be proud.

Very sincerely yours,
(Signed) Franklin D. Roosevelt.

It is gratifying to note that President Roosevelt has comprehensive knowledge of the work of the league. The original working plans as carried out through the League headquarters by Director General William D. Tracy and his staff still remain intact and the office of the Surgeon General has been informed that the league could quickly be brought into active service if needed.

An object of the celebration was to direct the attention of the younger members of the profession to this available plan through which the civilian dentist may serve his country by making the drafted man dentally fit for enlistment.

DENTAL ECONOMICS

A DISCUSSION OF THE SOCIAL SECURITY ACT, WITH SPECIAL REFERENCE TO THE HEALTH CLAUSES*

By C. T. MESSNER, D.D.S., F.A.C.D., Washington, D. C.

THE Social Security Act was passed by the Seventy-Fourth Congress and signed by the President, Aug. 14, 1935. Its purpose as stated in the general title of the Act is as follows:

To provide for the general welfare by establishing a system of Federal old age benefits, and by enabling the several States to make more adequate provision for aged persons, blind persons, dependent and crippled children, maternal and child welfare, public health, and the administration of their unemployment-compensation laws; to establish a Social Security Board; to raise revenue; and for other purposes.

Shortly after the passage of this act, the appropriation bill that provided funds to place the act in operation failed of enactment because of a filibuster in the Senate, and, as a result (at the time this was written), most of the provisions of the act have not been placed in operation. Another appropriation bill to supply the necessary funds is now before Congress and is expected to be passed about February 1. (The third deficiency appropriation passed the House January 24 and the Senate February 3, and was signed by the President on February 11. The appropriation to the Public Health Service for research in the amount of $550,000 was cut to $375,000. The appropriation for aid to state departments of health was five-twelfths of the total of $8,000,000, or $3,333,000.) The appropriations as carried in this bill are approximately five-twelfths of the total, as seven months of the present fiscal year (July 1, 1935-June 30, 1936) have already passed.

The act has eleven separate titles, as follows:

I. Grants to states for old age pensions.
II. Federal old age benefits.
III. Grants to states for unemployment-compensation administration.
IV. Grants to states for aid to dependent children.
V. Grants to states for maternal and child welfare.
VI. Public health work.
VII. Social Security Board.
VIII. Taxes with respect to unemployment.
IX. Tax on employers of eight persons or more.
X. Grants to states for aid to the blind.
XI. General provisions.

The act provides in title XI that if any of its provisions are held invalid, the remainder of the act shall not be affected thereby.

The Social Security Board is given responsibility for the federal administration of all grants-in-aid features of the act with the exception of certain titles pertaining to health. It is with the following health clauses that we are particularly concerned and regarding

*Read before the Section on Surgery, Radiology and Anesthesia at the Seventy-Second Annual Midwinter Clinic of the Chicago Dental Society, Feb. 19, 1936.

which I was asked to prepare this discussion:

Title V: Part 1, Maternal and child health services; Part 2, Services for crippled children; Part 3, child welfare services, to be administered by the Children's Bureau, U. S. Department of Labor.

Title V: Part 4, Vocational rehabilitation, to be administered by the Federal agency dealing with vocational rehabilitation, the Office of Education, U. S. Department of the Interior.

Title VI: Public health work, to be administered by the Public Health Service, U. S. Department of the Treasury.

The annual appropriations authorized for the Children's Bureau, U. S. Department of Labor, under grants to states for maternal and child welfare,[1] are as follows: Maternal and child health services, $3,800,000; services for crippled children, $2,850,000; child welfare services, $1,500,000; total, $8,150,000.

An annual appropriation of $425,000 is authorized to enable the Children's Bureau to carry on necessary administrative functions and to make such studies and investigations as may be necessary to promote the efficient administration of the parts of the act for which it is responsible.

Bulletin 1 states:

Examination of the provisions of title V which are concerned with maternal and child health, crippled children and child welfare shows that the primary purpose of these portions of the act is to extend and strengthen services for mothers and children in rural areas, in areas suffering from severe economic distress and among groups in special need. These are the people who have been hitherto, for the most part, outside the reach of health and welfare services that have been more generally available in the larger cities.

Allocation of these funds will be made to various state agencies, which will have administrative and supervisory responsibility. This may be to the state health agency, the state agency or agencies having responsibility for medical care for crippled children and the state public welfare agency. Emphasis is placed on the strengthening of local services in the states, relating to child health and child welfare.

The annual appropriation authorized for "maternal and child health services," in the amount of $3,800,000, is for the purpose of enabling each state to extend and improve, as far as practicable under the conditions in such state, services for promoting the health of mothers and children, especially in rural areas and in areas suffering from severe economic distress.

The annual appropriation authorized for "services for crippled children," in the amount of $2,850,000, is for the purpose of enabling each state to extend and improve (especially in rural areas and in areas suffering from severe economic distress), as far as is practicable under the conditions in such state, services for locating crippled children and for providing medical, surgical, corrective and other services and care, and facilities for diagnosis, hospitalization and after-care for children who are crippled or who are suffering from conditions that lead to crippling.

The annual appropriation authorized for "child welfare services," in the amount of $1,500,000, is for the purpose of enabling the United States, through the Children's Bureau, to cooperate with state public-welfare agencies in establishing, extending and strengthening, especially in predominantly rural areas, welfare services for the protection and care of homeless, dependent and neglected

1. Maternal and Child Welfare Bull. No. 1, Children's Bureau, U. S. Dept. of Labor, for sale by Supt. of Documents, Washington, D. C.; price, 10 cents.

children and children in danger of becoming delinquent.

The annual appropriation authorized to the U. S. Public Health Service, Department of the Treasury, for public health work, is as follows: For state health aid (to be allocated to the states), $8,000,000; for research, $2,000,000.

Section 601 of Article VI of the Social Security Act authorizes the annual appropriation of $8,000,000 "for the purpose of assisting states, counties, health districts and other political subdivisions of the states in establishing and maintaining adequate health services, including the training of personnel for state and local health work."

The $8,000,000 for aid to the states will be available for the following purposes: 1. Aid to state and territorial health departments for strengthening the service divisions and in providing adequate facilities for the promotion and administrative guidance of full-time city, county and district health service. 2. Aid through state and territorial health departments for the development of city, county and district health departments. 3. Training of public health personnel.

Grants will be made to the various state health departments on the basis of financial needs, population and special health problems. A certain percentage of the total will be allotted to each state as a flat grant, which need not be matched. An allotment will also be made to be matched by an existing state appropriation, while still another allotment must be matched by a new appropriation for public health purposes. The sum to be appropriated by the U. S. Public Health Service for the training of personnel is tentatively 12.5 per cent of the total, or $1,000,000.

All programs or projects must originate in the various states and shall be submitted to the Public Health Service for review and approval. It must be definitely understood that nominations of public health workers and other personnel are to be made by the state department of health and not by the U. S. Public Health Service. It is further required that the allotments be made to the fifty-one states and territories in accordance with the rules and regulations prescribed by the Surgeon General after consultation with the health authorities. Prior to their promulgation, the regulations must receive the approval of the Secretary of the Treasury.

PUBLIC HEALTH

Any agency or profession that has as its object the purpose of improving the physical well-being or the general welfare of the population *en masse* should have a well-established place in public health administration. Public health work aims at the promotion of individual and community health as well as the prevention of disease and is based on the fundamental needs of human welfare. Although it may deal with the problem of the individual, its greatest aim is in the standard of health of the community, despite the fact that community health is the sum total of individual health.

The protection and promotion of the public health have long been recognized as a responsibility of government. In the United States this responsibility has not generally been discharged in a systematic and adequate manner as have other functions of government, such as the protection of property, the provision of means of communication, the administration of justice and education. Furthermore, there is a marked inequality in the health service now being rendered to different communities, which results in a great difference of opportunity for citizens to acquire and maintain health. It is the aim of title VI of the Social Security Act,

among other purposes, to initiate a comprehensive, nation-wide program of public health, financially and technically aided by the federal government, but supported, as far as possible, and administered, by states and local communities.

POSSIBILITIES FOR DENTAL HEALTH PROGRAMS

Dentistry has long been recognized as an integral part of health service. Dental diseases among children and adults are more prevalent than all the other diseases combined; yet dentistry has not taken its proper place in the field of public health, for various reasons, the foremost of which are lack of facilities for training dentists in public health work, and the fact that no entirely adequate program covering all phases of dental health activities has as yet been developed.

The fact that the dentist deals almost entirely with abnormalities and diseases that are not communicable has, in my estimation, placed him in the background of public health administration; and yet every abnormality which he corrects in the oral cavity is but a distress signal of an outraged human mechanism. It is estimated that more than 90 per cent of all outside infections enter the body through the respiratory tract, and this fact alone should place the dentist in the front rank in the field of prevention. The relation of infection in and around the teeth to systemic conditions has been definitely established, and elimination of infective foci is recognized as an important factor in recovery from chronic diseases, as well as one of the main etiologic factors in many of the chronic diseases to which man is heir. Establishment of oral health should be the first step in the prevention of communicable diseases of the young, and maintenance of oral health through life will tend to reduce in proportion the degenerative diseases resulting from infection in the mouth in later years.

There has been no direct provision made for dentistry in the Social Security Act. This is probably due to the meager dental representation in the various state health departments, as well as the lack of interest of the dental profession in matters pertaining to public health. The survey of state health departments that was recently conducted by the Public Health Service revealed that only fourteen states had specific provision for the appointment of dentists on the state boards of health. Of the forty-eight states, there were only five employing full-time dentists in the state health departments. One other state employs a part-time dentist; three states employ dental hygienists, and two states employ teachers to take charge of their state dental health programs. A few of the larger cities have a full-time or part-time dentist with the city health department, but the majority of these are engaged in clinical work for school children. Only a very few are engaged in the broader aspects of public health administration.

The absence of interest of the dental profession in matters pertaining to public health is shown by the fact that only a very few dentists are members, or attend the meetings, of the American Public Health Association, and yet that association is interested and welcomes every branch of science that could be an aid or an instrument in the protection or promotion of public health.

The Association of State and Territorial Health Authorities, comprised of the active heads and members of the state health departments, is another organization dealing entirely with matters pertaining to health administration. If dentistry was represented in all state health departments, there is no doubt that the

dentists so employed would be deeply interested in an association wherein they could compare programs and discuss matters under their jurisdiction.

Fortunately, the organized dental profession is awakening to the fact that it must take active leadership in this field if it wishes dentistry to take its place along with the other branches of the health professions in public health administration. This was evidenced by the action of the House of Delegates of the A.D.A. at the last Annual Session, in New Orleans, in November. At that time, provision was made for a standing committee on public health whose duty it will be to promote and further dental health activities in the various state, city and local governments. This committee, with the backing of the organized dental profession, working in cooperation with the American Public Health Association, the Association of State and Territorial Health Authorities and the Public Health Service, should be able to arouse interest in establishing dental health programs in existing health organizations. If the dental profession can be properly stimulated, it has an opportunity, through the medium of the Social Security Act, to take a prominent place in health administration and education. This can be accomplished only by concerted and definite action.

A state dental society interested in a dental health program in its state should consult with the state health officer, advising him of its interest and offering to cooperate in establishing a dental health division in the state department of health. Many state health officers are deeply interested in this phase of health work, but because of a lack of interest on the part of the dental profession in his state, or because trained personnel are not available, or because of lack of funds, or an inadequate program, he has made no attempt to establish such a department in his organization.

It is only by a successful approach to the state health officer, by the local or state dental societies, convincing him of the urgent necessity for a dental health program in the state health department, that there is any chance for dentistry to obtain a part of this huge appropriation made by the government in the interests of public health. It is only through his recommendation to the Public Health Service of a project for a dental educational program in his state that such an allocation can be made from this fund.

The organized dental profession should take early and definite leadership in developing such a program, outlining its scope of activities not only for children but for adults as well, and for communities both large and small. Such a program should be flexible, one that may be used in part or in its entirety and that would coordinate with existing state health activities and the present administrative policies.

It should provide for a full-time dental director properly trained in public health administration. It should outline his qualifications and state the number of assistants and other personnel required. It should provide for a division of dental health in the state health department and show definitely why a dental section or unit under some other division will eventually tend to prevent the administration of dental health activities as they should be administered for all the public. It should be so developed as to stimulate and encourage existing local health agencies and professional societies in subdivisions of the state to meet or assist in meeting their own health problems. Such a program should have the indorsement of the various state dental societies, and a committee of the state societies should work

in close harmony with the state health department, giving encouragement and advice and also constructive criticism wherever it is needed.

FACILITIES FOR TRAINING PERSONNEL IN PUBLIC HEALTH WORK

Under provisions of the Social Security Act, it will be possible for the state health officers to recommend to the Public Health Service qualified personnel, including dentists, for training in public health administration.

Unfortunately, there are very few persons in the dental profession who are qualified to carry out and administer a well-rounded program of dental health. Consequently, this opportunity to train persons with the proper educational background in the fundamental principles of public health at one of the established public health schools is one that should not be overlooked.

It would be much more sound to delay establishing a dental health program until properly trained personnel are available than to attempt to inaugurate a program that in all likelihood would be inadequate and improperly administered. Therefore, if the state or local dental societies are interested they should consult with the officials of the state health department and recommend to him some member of their society whom they believe could be developed by proper training in a school of public health. In case the state health officer approves of the plan, he may, if he so desires, recommend a dentist to the Public Health Service for training purposes, with the understanding that, at the completion of the training course, a dental division will be established in his department.

If the Public Health Service approves this recommendation, it can, under the provisions of the act, make an allotment to the state that will cover the transportation of the dentist from his home to the training school, pay him a reasonable stipend while he is undergoing training, pay the tuition and laboratory fees and return him to his field of activity. The stipends will be comparable to those paid during training in the past by the Rockefeller Foundation, approximately $150 to $200 a month.

At a conference of the State and Territorial Health Authorities, June 17-19, 1935, a committee appointed to draw up qualifications for health officers and health personnel made recommendations covering health officers, public health nursing positions, sanitation personnel, public health engineers, sanitariums and sanitary officers. In a lengthy report, they made no mention of qualifications or training for dental personnel. This was perhaps an oversight.

The conference recommended that $1,000,000, or 12.5 per cent of the $8,000,000 appropriation, be set aside for the prompt development of qualified personnel designed to strengthen and enlarge the staffs of state and local health departments. In furthering these objectives, it was recommended that the Public Health Service proceed to develop suitable training centers at existing institutions, conveniently located to serve certain groups of states.

In formulating these standards of training, the committee of the conference followed closely the report of the Committee on Professional Education of the American Public Health Association. For health officers for small centers of population or who would work under supervision, a short course of two months was provided.

At the same conference, a committee report was adopted on "Qualifications for Health Officers and Health Personnel." Their recommendations for training health officers were as follows:

I. Basic educational requirements shall be:

A. The degree of doctor of medicine from a reputable school and eligibility to examination for medical licensure in the state where service is to be rendered.

B. Not less than one year of clinical experience, gained preferably in a hospital of acceptable standards. Preference shall be given to candidates whose clinical experience includes three months' hospital work in pediatrics and a similar period in infectious diseases.

II. Special qualifications:

A. Pending the development of a reserve of personnel having graduate training in public health work, the following minimum qualifications shall apply as a standard in the selection of medical officers of health for jurisdictions of less than 50,000:

1. Candidates for appointment shall be not more than 35 years of age when first specializing in public health work. Preference shall be given to candidates having had one or more years' experience in the general practice of medicine.

2. Personnel selected shall already have had or shall agree to take before assuming duty not less than three months of special training in public health, of which not less than two months shall be organized instruction in an approved academic institution and one month in field apprenticeship in an approved local health organization.

B. For health officers of jurisdiction having populations of more than 50,000, for staff positions with state health departments, and for positions having the responsibility of supervisory and consultant service, the following standard of qualifications shall apply:

1. Not less than one year in residence at a recognized university school of public health and the satisfactory completion of a course of study in the fundamental subjects in preventive medicine:

a. Such knowledge of biostatistics as will give the individual a sound conception of the mass phenomena of disease, familiarity with the methods of collecting, recording and studying statistics on vital phenomena, and ability to interpret the results of the analysis of such material.

b. Some knowledge of general or theoretical epidemiology and training in the collection, recording, analysis and interpretation of epidemiologic information regarding the commoner diseases, including occupational diseases and industrial hazards.

c. Familiarity with the general historical background of health administration, a general knowledge of the forms and methods of operation of health departments of the national government, and of the states and local units, and acquaintance with the standard procedures of health administration.

d. Sufficient knowledge of public health bacteriology and immunology to permit the performance personally of the simple diagnostic procedures, the interpretation of laboratory reports and familiarity with the general methods of administration and operation of public health laboratories.

e. General knowledge of the usual methods of water purification and sewage disposal, sufficient to enable the individual intelligently to advise the local authorities in securing engineering advice and in undertaking new procedures.

f. Familiarity with the dangers from, and the general methods of securing protection against, diseases transmitted by foods.

g. Sufficient familiarity with the clinical aspects of the commoner communicable diseases to serve as a basis for developing skill in differential diagnosis and advising as to treatment. Complete and accurate knowledge of the possibilities, limitations and practical methods of immunization against communicable diseases.

h. Sufficient knowledge of the epidemiology and clinical aspects of tuberculosis to enable the individual to plan and administer methods of prevention.

i. Sufficient knowledge of the epidemiologic, clinical, and social aspects of venereal disease, to enable the individual intelligently to plan and administer preventive procedures.

j. Familiarity with the principles of nutrition. He should possess a knowledge of

basic food requirements. Not only those that are necessary to life, but also those which represent optimum conditions for production of the greater vigor and stamina. He should have sufficient knowledge to recognize these actual clinical entities that may be produced by a faulty dietary.

k. Sufficient familiarity with the clinical aspects of the common occupational diseases to serve as a basis for developing skill in differential diagnosis and advising as to treatment, and accurate knowledge of the possibilities, limitations and practical methods of control of occupational diseases.

2. Not less than six weeks of field experience under proper supervision in a suitable health organization.

Public health education is founded upon a broad knowledge of public health administration, epidemiology, biostatistics and sanitation. All other subjects are considered specialties. It is the opinion of the Public Health Service that dentists engaged in public health administration, especially in charge of a division in the state health department, should be given this basic public health course covering a period of one year, the same as for physicians assigned to equally responsible duties. Hence, we may take it for granted that a graduate in dentistry entering the field of public health will, and should be required to, meet the same requirements with respect to fundamental scientific training as other public health workers.

In addition to the basic course, the dentist should be instructed in his specialty, dental health education, as outlined in a proposed program of oral health administration.

This federal legislation gives the dental profession an opportunity definitely to place dentistry in its proper place in existing public health organizations and activities. If dentistry does not assume this leadership at this time, it will be doubly difficult in the future to dovetail dental programs with other health activities that will be enlarged and stimulated by this federal assistance. Mental hygiene, industrial hygiene and various other branches of health work are awakening to the fact that here is an opportunity never before offered to those engaged in public health activities to coordinate the various branches of health administration into one public health program, which may include all the intricate ramifications in preventing disease and promoting public health.

F. I. Livingston, Ashern, Canada, in discussing prevention as the term is commonly used by dentists, says:

> Rather, it is in the field of public health that the observant clinician may see and ponder over the effects of nationality, heredity, diet, water supplies, living conditions and occupational pursuits, and from these evolve theories for testing and adoption. From this laboratory eventually will emerge the true preventive dentistry. Slowly and painfully, it will evolve from the womb of mass suffering and not from the left over fragments of dental courses.[2]

RESEARCH

Title VI of the Society Security Act authorizes an annual appropriation of $2,000,000 to the Public Health Service for research. This appropriation may be used by the Public Health Service for research purposes at the Public Health Service National Institute of Health, other Public Health Service research laboratories and hospitals or in field studies, or portions of it may be set aside for cooperative studies with universities, individuals or private laboratories, to assist some existing research.

The appropriation bill now in Congress carries $500,000 for this purpose for the balance of the present fiscal year. Out of this amount, $36,000 has been

2. Livingston, F. I.: Prevention—Just Another Word? J.A.D.A., 22:2158 (Dec.) 1935.

tentatively set aside to continue the studies in dental research that are now being conducted by Public Health Service officers, and $16,000 to initiate new studies. It is also believed that at least one cooperative project with a university for dental research may be developed. In addition to this, the facilities of all departments of the National Institute of Health and other existing Public Health Service laboratories are available for consultation and advice. Thus, it would seem that dental problems are not being neglected by the government.

SUMMARY

The Social Security Act, which is now a law, contains broad health provisions. The authorized appropriation of $8,150,000 to the Children's Bureau, U. S. Department of Labor, for maternal and child health services, services for crippled children and child welfare services, all of which will be allocated to states under definite regulation, is in the interests of the health and welfare of the more unfortunate children, crippled children or those who are suffering from conditions that lead to crippling.

The authorized appropriation of $8,000,000 to the U. S. Public Health Service for the purpose of assisting states, counties, health districts and other political subdivisions of the states, in establishing and maintaining adequate health services, including the training of personnel, is for the purpose of developing a comprehensive, nation-wide program of public health, financially and technically aided by the federal government, but supported as far as possible and administered by states and local communities.

The authorized appropriation of $2,000,000 to the U. S. Public Health Service for research into diseases that affect man is an effort on the part of our national government to assist in the search for health.

The map of the world was many years in the making, but it is now almost complete. In the fields of medicine and dentistry and other sciences in their search into diseases which directly or indirectly affect man, and which has been in progress since the beginning of time, there are still vast wildernesses untrod by human feet, secret places that no eye has seen, buried treasure yet unfound. Just around the corner, around many corners, are wonderful new things; for the world of medicine is new, is not half explored; its wealth and possibilities are yet unrealized. The care of the sick through all the ages has been the index of the progress of human civilization.

A CRITIQUE ON "THE PATIENT'S DILEMMA" (CHAPTER 11)

By EDWARD H. OCHSNER, B.S., M.D., F.A.C.S., Chicago, Ill.

THE first ten chapters (222 pages) of the book "The Patient's Dilemma," by S. A. Tannenbaum, M.D., and Paul Maeker Branden, are so admirably reviewed in the editorial, "A Certain Amount of Muck-Raking," (page 685, this issue) that I shall confine my analysis entirely to the chapter, "Physician, Heal Thyself!" the last forty-nine pages of the book.

This chapter consists of scores of dogmatic assertions, some of which are utterly ridiculous, many entirely illogical, others contradictory, again others gross exaggerations and a good many clearly at variance with definitely known facts. In order to do a thorough job of debunking and disproving all of the statements that come under one or the other of the foregoing classifications, enough material to fill several volumes would have to be presented. There is not so much space available here, nor does the chapter really merit so much time and trouble; but I cannot refrain from discussing a few of its most ridiculous, exaggerated and fallacious claims.

In reference to the question as to whether it would be wise to pay dispensary and clinic physicians, the author asks: "Would there be policemen enough to prevent the doctors from maiming or killing one another in the scramble for jobs paying, perhaps, thirty dollars per month?"

The authors bewail the meager income of American physicians in the following:

> That opportunities for earning a living from the legitimate practice of medicine are very limited may be concluded from the fact that—even with racketeering!—the average American doctor was able to earn only a net income of about five thousand dollars in 1929, the peak year in the Era of Prosperity. It may be added that in the same year fifty per cent of doctors in the United States had a net income of only thirty-eight hundred dollars, twenty-five per cent of only fifteen hundred dollars.

Even that is not so bad as it may seem when we compare it with what doctors receive under state medicine and compulsory health insurance. The regular pay for state physicians in Russia is, I am most reliably informed, 250 rubles per month, or approximately $1,500 a year. Few English panel physicians have an income over £500, or $2,500, a year, and out of this they have to provide offices and transportation at their own expense. The German *Krankenkasse* physician gets 1 mark (24 cents) for an office visit and 2 marks (48 cents) for a house call, also with transportation and office facilities at his own expense. As a result, either he has to make his visits and examinations most hurriedly and superficially, or he barely ekes out a living; usually both.

All through the chapter, the authors try to convey the impression that all patients need extensive and expensive examinations:

> A diagnosis now not only involves a careful chemical and microscopical examination of urine, blood, sputum, stomach contents, fecal excreta and spinal fluid, but also one or more series of X-ray photographs, electrocardiograms, proctoscopic, cystoscopic and ureteral examinations, and the like. These procedures are expensive and may have to be repeated more than once during the course of an illness. From a financial viewpoint an attack of sickness, requiring any or several of these examinations, may well prove catastrophic—to the patient.

Not one case in 10,000 that comes to the general practitioner for routine diagnosis needs *all* of these diagnostic procedures; and only a very small percentage need more than the careful examiner can provide by the use of his five senses and by the use of the ordinary facilities for routine laboratory examinations that every physician can and should have at his disposal, and can and should be able to use himself. In addition, there is not one scintilla of evidence that in those countries that have compulsory health insurance, patients, as a general rule, actually have better or even so good diagnostic procedures available as they do in this country.

> . . . that only a very small percentage of the American public is receiving proper

medical care; that millions of people here have died for want of suitable medical care. . . .

The foregoing statements are such gross exaggerations of the actual facts that they do not need refutation. There is no evidence to support either of them, and the latter statement does not even specify during what period of time the millions have died. Does the author include all time since the discovery of America or only the last twenty years? If the former, the statement is irrelevant, for what happened 100 years ago can scarcely be blamed on the present time, and if it refers only to, say, the last twenty years, it is manifestly untrue.

Feb. 26, 1936, the following item appeared in the *Chicago Daily Tribune:*

The school my youngster attends is in Edgewater, and I have taken her to the school doctor after an absence from school for various reasons. The children are lined up in a big basement room, empty except for a table and chair, and there await the doctor. In he comes at almost a run. He doesn't take his coat off, or sit down. He tells the children to hurry forward and stick out their tongues; if the tongue looks anywhere near normal he O. K.'s the notes the children must have (although he doesn't read them nor ask what has been the trouble). If a child coughs like the dickens, he doesn't hear it, but puts on his kelly and dashes off again. Is that all he is supposed to do? I wonder.

This is typical of the service that most school doctors give. Is it not illogical, then, to expect a government, which in minor matters renders only mediocre service, to render practically perfect service when it is entirely controlled by the state? This is exactly what this book advocates and claims for state medical service. All known facts contradict this claim. Volumes of evidence could be collected on this phase of the problem alone. The following will have to suffice. Frank L. Rector,[1] M.D., who made a survey of health and medical work in all state and federal prisons and adult reformatories, says unequivocally that in not one of these institutions is there a well-rounded, balanced medical and health program.

The authors admit that there is a ". . . large increase in the number of people on the sick list . . ." but try to explain it away by saying that this ". . . is not due to malingering, but to the fact that education has made the public health-conscious and has taught them the value of obtaining medical assistance as early as possible." Then, why, if the German laboring man is thus health conscious and has medical care so much earlier, does he lose more than twice as many days every year because of illness than does the American laborer? Not only that, but the mortality rate in comparable areas is higher in Germany than in America.[2]

The authors repeatedly make the assertion that malingering is rare. This statement is not supported by the evidence nor by the statements of careful German observers. Thus, Baeumer[3] says that in Germany they call these people *Simulanten* (simulators). If, instead, they would call them by their right names, "thieves," and put them where they belonged, in prisons, the German nation could not find enough money to build prisons to hold them all. The best evidence that malingering is extensively practiced is furnished by the fact that on the very day a person reports himself sick, a lay inspector is sent to the house to investigate whether the patient is really sick or

1. Rector, F. L.: Health & Medical Services in American Prisons and Reformatories.

2. Ochsner, E. H.: Social Security, Chicago: Social Security Press.

3. Baeumer, Waldemar: Die Kranken Versicherung, Munich: J. F. Lehman.

is just pretending sickness; and also by the fact that, in Germany, the authorities have adopted hundreds of rules in trying to check the abuses, but have utterly failed to do so. As soon as a new rule is established, the clientele discovers a new method of evading it.

The authors also make the following statement: ". . . the public would save millions of dollars which now are wasted on nostrums and cultists . . ." This statement prompts me to ask the following question: How then, does it happen that, in Germany, where compulsory health insurance, the very system which is so highly lauded by the authors, has been operating the longest, cultists have so tremendously increased? In 1876, seven years before the introduction of compulsory health insurance in Germany, the number of lay practitioners or cultists, as compared to the number of regular practitioners of medicine, was 4.9 per cent; while, in 1926, forty-six years after the introduction of compulsory health insurance, the number of cultists had risen to 26.1 per cent.

Much space is taken up in discussing the largely imaginary evils of competition among the practitioners of medicine in this country, but the authors neglect to state the well-known fact that competition is much more severe and much more ruthless, and manifests itself in a much more vicious manner, in countries like Germany. It is also a well-authenticated fact that under compulsory health insurance, it is not the best and most experienced physician who has the largest practice, but quite generally he who is the most liberal with sickness certificates; and the best and most competent physician is not the one to get advancements, the most astute politician and the best political wire-puller landing the most desirable plums under this system.

The frequent repetition of the words "racket" and "racketeering" in reference to the practice of medicine and the practitioners of medicine is a gross slander on the rank and file of the medical practitioners of this country. I do not know of a finer, more unselfish, more efficient and more honorable group of persons than the doctors, dentists and nurses who look after the health welfare of the citizens of our nation. The American people today are getting as good medical services as any people on the face of the earth, and better medical services than most of the people who are living in countries that have extensive compulsory health insurance systems.

To prove this statement, we need but compare American morbidity and mortality statistics with those of Germany. Comparable statistics are easily available. In Germany, it is definitely proved that compulsory health insurance has not reduced the number of days per year lost from illness; it has not reduced the mortality as compared with that of those countries which do not have compulsory health insurance, and it has not reduced the cost of sickness to the nation as a whole.

If not, what on earth is it good for? Suffice it to say, at this point, that practically every statement in the chapter under consideration in favor of socialized medicine has been disproved over and over again. Haeckel was evidently right when he said, "History teaches us nothing except that it teaches us nothing.' This holds true at least, as far as the medical author of the chapter, "Physician, Heal Thyself!" is concerned. The entire chapter is such a mass of exaggerations and misstatements that it will not convince any one who will use his head, not just for a hat rack, but for what it is intended for, namely, to think things through to their logical conclusions. However, such a book is a real menace in that it will

make those who are prejudiced still more so; and anything which fosters prejudice is bad, as prejudice is one of the most serious handicaps to human progress.

2155 Cleveland Avenue.

HEALTH SECURITY AND THE AMERICAN PUBLIC—A RADIO DISCUSSION

On March 5, 1936, America's Town Meeting of the Air presented a very interesting radio program entitled "Health Security and the American Public." The speakers were Michael M. Davis, Ph.D., medical director of the Rosenwald Fund and Morris Fishbein, M.D., Editor of the *Journal of the American Medical Association.* If you did not hear this discussion, you missed a real treat. Reprints can be secured from the American Book Company, 88 Lexington Ave., New York City; price 10 cents each.

CURRENT LITERATURE

Congenital Defects (D. P. Murphy, J.A.M.A., 106:457 [Feb. 1] 1936): In a study of 275 families each known to have possessed a congenitally malformed or defective child and also one or more subsequent children, it was found that in 12.4 per cent additional malformed children appeared. In 431 conceptions following the birth of malformed children, 76.8 per cent resulted in normal, full-term infants, 10 per cent in congenitally malformed children, 10 per cent miscarriages, 2 per cent premature births and 1.5 per cent still-births. In families having one congenitally malformed infant, a second one was born once in every eight and nine-tenths births, against one in every 213 births in the general population. It is concluded that serious congenital malformations, i. e., recorded on death certificates, are about twenty-four times as likely to occur in families already possessing congenitally malformed children as in the general population.

HAMILTON ROBINSON.

Measurement of Roentgen-Ray Absorption Coefficients in Tooth Sections (Franklin Hollander, Proc. Soc. Exper. Biol. & Med., 33:388, 1935): In order to measure the changes known to be significant but of the order of less than 5 per cent of the roentgen-ray absorption of tooth slabs, a grenz ray machine with a double ionization chamber and a string electrometer is described, which gives determinations with an error of ± 0.5 per cent.

HAROLD C. HODGE.

Microscopic Investigation of Innervation of Tooth and Its Surroundings (H. B. Van der Sprenkel, J. Anat., 70:233 [Jan.] 1936): Several methods were used to make this study, including the Bielschowsky-Gros silver impregnation and the de Castro-somnifen. The author modified the technics in order that they might be adaptable to the material. He traced the fibers of the pulp into the dentinal canals and thus was able to eliminate the possibility of confusion with the Tomes processes. The nerves entered the pulp with the blood vessels and soon became separated from them. The fibers were of the medullated and the nonmedullated types, all of which in their terminal parts are nonmedullated. He describes a nerve plexus under the odontoblastic layer as well as a supraplexus from which the fibers pass into the dentinal tubuli. He does not believe that the nerves end as free-endings in the pulpal tissue or that they end around the odontoblasts, which would make them a neurosensory cell. He conjectures that the fibers may pass into the deep layers of the enamel as he believes that the Tomes processes are continuous into the enamel. In the peri-

dental membrane, he describes three types of endings: (1) a ring around the cells that are present in the tissue; (2) a ring resting on the collagenous bundles of the membrane to which it is attached by a perireticulum, which he believes is to provide a perception of pressure by the stretching when the tooth is moved, and (3) some nerve fibers which pass from the peridental membrane into the dentinal canals and which he believes to be functional in the touch and pressure perception. In the conclusions, it is stated that the nerve fibers may act reflexly for the regulation of the acts of mastication.

M. W. McCrea.

Nasopalatine Duct Cysts (Moses Goodman, Radiology, 26:151 [Feb.] 1936): Nasopalatine duct cysts are formed in the incisal canal of the maxilla and originate in the nasopalatine duct. They are often erroneously interpreted as cysts at the apex of the anterior teeth and are passed up as an enlarged incised foramen. They have also been considered as supernumerary paranasal sinuses. According to Schroff, nasopalatine duct cysts may (1) result from intra-oral trauma to the papilla palatina; (2) have a dental origin, owing to infection from the central incisor teeth extending into the canal, or (3) have a nasal origin, owing to extension of infection of the nasal mucosa. The possibility of the presence of a nasopalatine duct cyst should be considered whenever dental roentgenograms from this area are being interpreted.

J. Frank Hall.

Use of Azochloramid in Infected Wounds (R. H. Kennedy, Am. J. Surg., 31:294 [Feb.] 1936): Studies on the use of azochloramid, a substitute for the more unstable Dakin's solution (surgical solution of chlorinated soda), is described. Treating wounds with azochloramid resulted in removal of bacteria. No selective bactericidal action was noted. There was no evidence of destructive effect on tissues. No systemic toxic effects were noted after local use. It was not found harmful in as low as 1:3,300 aqueous solution or 1:400 in oil. Greater concentration than this was found unnecessary. It did not show solvent action on dead tissue. No evidence of digestion of newly formed epithelium was found and in only 10 per cent of the cases was even a mild skin irritation noted. Tissue repair seemed to progress normally during its use. It seemed to be safe for use in pleural and peritoneal cavities. It evidently has similar action in oily or aqueous solution. Only one disadvantage, failure to dissolve dead tissue, is listed against six advantages over other antiseptics. The use of azochloramid is recommended in several surgical conditions including prophylaxis in closed lacerated wounds, whether debrided or not, prophylaxis in unclosed compound fractures after débridement and in infected wounds and abscesses of all types except when gross slough or foreign bodies have not been removed.

Hamilton Robinson.

Treatment of Carcinoma of Larynx (G. B. New and F. A. Figi, Surg. Gynec. & Obst., 62:420 [Feb. 15] 1936): The surgical technic for treatment of carcinoma of the larynx should not be definitely decided on before operation. Rather, there should be an exploratory operation, with everything in readiness, and the procedure so planned that is best suited for the individual case. Carcinomas are classified as: (1) intrinsic, those originating on the vocal cords which metastasize late, owing to the lack of lymphatic drainage and (2) extrinsic, those which are early in metastasizing and affect the epiglottis and aryepiglottic fold. The author discusses a large number of cases at the Mayo Clinic over a period of several years and explains their follow-up system. Sarcomas and adenomas are mentioned. The symptoms and surgical treatment for the individual cases are fully explained. The method of surgical treatment for carcinoma of the larynx should leave the patient with a good voice when it is at all possible.

J. Frank Hall.

Development of Tooth Germs in Vitro (S. Glasstone, J. Anat., 70:260 [Jan.] 1936): The tooth germs of 18-20 day embryo rats were removed and explanted in

part and *in toto*. These were grown on a medium consisting of embryo extract, fowl plasma and Compton's solution by the hanging drop and watch glass technics. It was found that the odontoblasts of the dentinal papilla deposited normal tubular dentin only when the internal enamel epithelium was present. The epithelium was only necessary to the formation of the odontoblasts and fully formed odontoblasts were found to form dentin without the epithelium. It is stated that the enamel organ determines the morphologic structure of the tooth. Comparative studies of the explants were made with the tooth germs of the opposite side, which were prepared by the usual histologic technics. It was found that the explants of 20 days were not developed any more than a four-day growth of normal environment. In some of the explants, a scar tissue formed that was comparable to that found in teeth of animals that suffered from scurvy. This is, to the author's knowledge, the first report of *in vitro* experiments on tooth germs grown on artificial media.

M. W. McCrea.

(Pinkerton and Boyle reported *in vitro* cultivation of tissues from the enamel organ and dental pulp at the meeting of the International Association for Dental Research, in March, 1935. Their paper, read by title, is presented in abstract form in the Journal of Dental Research, [15:221 (June-August) 1935].)

Résumé of One Hundred Transantro-Ethmosphenoid Operations (Charles E. Futch, Surg. Gynec. & Obst., 62:509 [Feb. 15] 1936): This report of complete sinus surgery, or transantrum technic, permits the elimination of pathologic processes from the antrum, ethmoids and sphenoids at one operation. The history of the patient and clinical and roentgen-ray diagnoses were carefully considered in each of the 100 cases. Basal anesthesia with avertin was a valuable adjunct to the usual cocaine and block anesthesia. Hemorrhage was controlled as usual at the time of operation and it was necessary to employ packing in a number of cases after the operation. The external carotid was ligated in two cases. In two other cases, drainage of spinal fluid was present for four days. Pulmonary embolism occurred in one case. There were no complications and no pronounced loss of the olfactory sense. In one case of tic douloureux, the patient has been relieved since operation, two years ago.

J. Frank Hall.

Betel Chewing in Relation to Oral Sepsis and Carcinoma, (W. Balendra, Antiseptic, 32:570, 1935; abstr. Am. J. Cancer, 26: 426, 1935): About 90 per cent of the whole population of India and Ceylon indulge in betel nut chewing and 94 per cent of the patients with oral carcinoma are addicts. Of the malignant conditions observed in the mouth, about 90 per cent were on the mandible and adjoining teeth, 8 per cent on the tongue and 1 per cent on the lip. The teeth of addicts become brittle and sharp through erosion and irritate the soft tissue. As the betel is often chewed with tobacco leaves, another factor of irritation is added. The process leading to malignancy is characterized by extreme slowness, few persons developing true malignant growths in less than from fifteen to twenty years.

Hamilton Robinson.

Radium Treatment of Postoperative Parotitis (Harry H. Bowing and Robert E. Fricke, Radiology, 26:37 [Jan.] 1936): Acute parotitis, although rare, has for many years been recognized as a very serious postoperative infection. Formerly, operation on the genital organs was considered the type most likely to be followed by acute infection of the parotid glands. Blair, and Padgett, of Germany, reported fourteen cases, with 50 per cent mortality. Green, in 1935, made a survey of acute parotitis following operations, and found it occurring only once in 2,275 general operations. Rankin and Palmer reported fifty-eight cases from The Mayo Clinic, with a death rate of 39 per cent, and occurring more often after colon and rectum, than after pelvic, operations. The most important etiologic theories are: (1) the pyemic theory, ac-

cording to which a septic clot from the primary focus of infection forms an embolus in a parotid vessel, and (2) the theory of infection of the duct, according to which secondary parotitis is caused by direct extension of micro-organisms along Stensen's duct from the mouth. The authors report 184 cases treated with radium at The Mayo Clinic between 1929 and 1934, including twenty cases reported by Rankin and Palmer. The patients range in age from 7 to 76 years, with an age average of 50 years, including ninety-five males and eighty-nine females. The mortality, grossly, was 22.8 per cent, but discounting six deaths of moribund patients, which occurred before treatment could be more than started, the true mortality rate was 19.6 per cent. They find that the largest incidence follows colonic surgery. The necessary withholding of food and fluids by mouth for several days after operation, the effect of the opiates required and the absorption from intestinal stasis may all play a rôle.

J. FRANK HALL.

FOREIGN LITERATURE

Mycotic Infection of Buccal Mucosa Caused by Leptothrix (F. Petocka and J. Obrtel, Ceská dermat., 15:206, 1935; abstr. Arch. Derm. & Syph., 33:336, 1935): A healthy, 36-year old man, presenting evidence of good oral hygiene, showed a hard, shiny, white diphtheria-like membrane the size of a dime and with several satellite lesions under the tongue. No inflammatory reaction could be seen in the surrounding mucosa and a slight increase in salivation and a sensation of the presence of a foreign body were the only subjective symptoms. After the two years' treatment, a slight extension of the pseudo-membrane was noted. Two types of leptothrix, not conforming to any known species and therefore designated as types A and B, were isolated and grown in pure culture. No pathogenicity was evidenced on inoculation of animals. Antigens prepared from the cultures gave negative intracutaneous reaction, but type A produced an inflammatory reaction in controls.

HAMILTON ROBINSON.

MISCELLANY

BOOK REVIEWS

Dental Infection and Systemic Disease. By Russell L. Haden, M.A., M.D., Chief of the Medical Division, Cleveland Clinic, Cleveland, Ohio; Formerly Professor of Experimental Medicine, University of Kansas School of Medicine, Kansas City, Kan.; Formerly Director of Medical Research, Deaner Institute, Kansas City, Mo. With a foreword by Dr. Edward C. Rosenow. Second edition, revised. Illustrated with 63 engravings. 163 pages. Price, $2.50. Published by Lea & Febiger, Philadelphia, 1936.

The question of the real significance of the seriousness or otherwise of focal infection connected with the teeth is still a long way from being settled. This book presents one side of the question quite emphatically and quite ably. It represents a point of view gained from impressions about the teeth and mouth, and not from experience with the teeth and mouth. It is the point of view of the medical man, who naturally wants to eliminate all infection from the mouth; but the question might logically be raised as to whether he is sufficiently familiar with the subject from practical experience to judge certain manifestations in the mouth that are matters of every-day knowledge and conviction to those who are well-grounded in the subject. A medical man is to be commended for wanting to eliminate infection, but it is proper to demand of him that he become sufficiently familiar with the subject to be justified in passing judgment in the case. Too much harm has been done by creating fear of trouble when there was no justification. It is a matter of common knowledge that

countless thousands of perfectly healthy and serviceable teeth have been sacrificed through the fear engendered by false propaganda.

Granted that everything said in this book is absolutely true, and granted that all of the harm depicted is subject to demonstration, it is doubtful that this harm can ever measure up to the harm that has unwittingly been done to the people by misjudgment on this subject of focal infection. The inference that all pulpless teeth are dangerous is simply not true. Moderation on this whole question would serve a useful purpose and lead to less harm. The advice is to study this book with an open mind, but not to take anything for granted that is not capable of practical demonstration.

The Patient and the Weather. By William F. Petersen, M.D., Volume I, Part I. The Footprint of Asclepius. 127 pages. Illustrated. Price, $3.75. Published by Edwards Brothers, Inc., Ann Arbor, Mich., 1935.

This is a fascinating study of the effect of the weather on the individual in different regions. The author has gone into the question in great detail, and the reader will want to pore over the volume at some length. The graphic form of illustrating the book will make this study quite easy, though of course there must be much conjecture. For instance: "What a wonderful time our descendants five hundred or a thousand years hence may have when they survey the race that will survive the everlasting, ever changing 'restlessness of the winds' which torment the souls and sear the bodies of the inhabitants of our northern latitudes."

Again: "The American is growing taller and his head more narrow. Boas and Hrdlicka both have adduced the evidence in this direction. And this we might anticipate, especially if the material is selected from the storm tracks."

There is something besides dentistry in this volume, and it is well worth reading.

You Must Eat Meat. Fancies, Foibles and Facts about Meat. By Max Ernest Jutte, M.D., Formerly Lecturer on Stomach and Intestinal Diseases, New York Polyclinic Medical School; Member of the American Medical Association, New York State Medical Society; Corresponding Member of the Société de Médecine de Paris. 164 pages. Price, $2. Published by G. P. Putnam's Sons, New York City, 1936.

If a subtitle had been given this book, it surely would have been "The Case for Meat." And in view of all the cults and worse than cults that have been urged against the eating of meat, it is perhaps necessary to have something said on behalf of meat as a diet. In this volume, emphasis is given to the great virtue of meat as a "blood builder," and the argument is continued all through the book as to the virtues of meat and the limitations and possible dangers of a strictly vegetable diet. Partisanship on the question of diet seems almost inevitable, and if readers listened to all the radical theories that are propounded, they would at least be confused. This book has many valuable suggestions as to regulating diet, and it will be read with interest. At least, it should do away with certain of the blind prejudices that have been built up against meat as a diet, and lead to a more rational attitude on the entire subject of human diet.

Dental Materia Medica, Pharmacology and Therapeutics. By Walter J. Dilling, M.B. Ch.B. (Aberd.) Professor of Pharmacology and General Therapeutics, School of Dental Surgery, The University of Liverpool; Examiner in Pharmacology for the Universities of Cambridge and St. Andrews, and for the Examining Board of the Royal College of Physicians and Surgeons of England; Formerly Examiner in the Universities of Belfast, Cardiff, Leeds, London and Oxford, and Samuel Hallam, L.D.S., R.C.S. (Engl.) Honorary Dental Surgeon, Liverpool Royal Infirmary, Consulting Dental Surgeon, Liverpool Maternity Hospital, Consulting Dental Surgeon, Western Command; Member of the Board of Dental Studies, Liverpool University. 328 pages. Price 10s 6d. net. Published by Cassell and Company, Ltd., La Belle Sauvage, London, E. C. 4.

An early observation of the authors will

bear extended consideration. This relates to the desirability of concentrating on the prevention of disease rather than on its cure. More and more insistence must be had on this idea, and while we do not yet seem to be able to prevent disease to the extent that we should, it is encouraging to note that there is a growing interest in the theory of prevention and a constant effort to bring about its consummation. A short though useful chapter in the book is that on prescription writing, suggesting that dentists should learn to write prescriptions instead of handing out prepared slips for proprietary products. A chapter is included on filling materials, and while brief in treatment and lacking in detail, it is worthy of study. The book as a whole must commend itself to the consideration of the reader, and there will be found many useful suggestions that will well repay careful study.

American Chamber of Horrors. The Truth About Food and Drugs. By Ruth deForest Lamb. Illustrated with photographs. 418 pages. Price, $2.50 net. Published by Farrar & Rinehart, Inc., New York City.

It seems the most amazing thing in the world that the public persists so tenaciously in furthering its own destruction by the deliberate use of products that are known to be useless or harmful. All along the line, the fight has continued for years to suppress products of uncertain value or of known harm, yet with all of the force of the government behind the movement, progress has been discouragingly slow. Here a little and there a little, the agencies of honesty and decency have broken down the bars and exposed to the light of day the nefarious processes and products of the profiteer, but on the whole the fight has been an uphill one. The present book is an effort to bring before the public certain of the iniquities of the situation, and it seeks to portray "The inside story of the government's fight to protect consumers against dangers to health, life and pocketbook." While the chapter on exploitation is a sad one, it is only by continued vigilance that the forces of evil can be broken down. This book is an exposé of many of the doubtful and worse than doubtful products presented to the public and the list is so long that it constitutes itself a serious reflection on the average intelligence of the public.

The Principles of Dental Medicine. The Medical Aspects of Dental Disease. By F. W. Broderick, M.R.C.S. (Eng.), L.R.C.P. (Lond.), L.D.S. (Eng.). Hon. Dental Physician to the Royal Victoria and West Hants Hospital; Hon. Dental Surgeon to the National Sanatorium for Diseases of the Chest, Bournemouth; Cartwright Prizeman, Royal College of Surgeons, England, 1926-1931. Second edition, revised and rewritten. With 27 illustrations. 575 pages. Price, $7.50. Published by the C. V. Mosby Company, St. Louis, 1936.

To write anything like a comprehensive review of this book would be to write a book in itself. The author has employed the seven years since the first edition was issued in elaborating his previous work, and, like a good artisan, he has improved his product. But at the end of it all, he has this to say: "Notwithstanding an immense amount of painstaking work undertaken during the last twenty years, we seem to be but little nearer to the solution of our problem of the true understanding of the causes of the prevalence of dental disease amongst civilized peoples. It looks as if it should be so easy of accomplishment with so many carefully collected and correlated facts before us, yet each of the almost numberless suggestions that have been brought forward, one after the other, fails to satisfy dentists that we have at least reached a position when preventive dentistry has become a practical proposition." And there you are. The author of this volume has made an honest effort—almost a heroic effort—to throw practical light on this problem. He has quoted various authors with their various theories, only to be thrown back on one hypothesis after another, to the end that little of a conclusive nature has been evolved. Yet in justice it should be said that, in the attempt to formulate and systematize the current theories of the day, the author has garnered and brought into relief most of the logical

advanced thought on the subject and marshalled it for the benefit of the reader. To accomplish this has been no small task, and the book will therefore well repay reading and study.

Dental Roentgenology. By LeRoy M. Ennis, D.D.S., Assistant Professor of Roentgenology in the Thomas W. Evans Museum and Dental Institute, School of Dentistry, University of Pennsylvania; Instructor in Dental Roentgenology in the Graduate School of Medicine, University of Pennsylvania; Lieutenant Commander, U. S. Navy Reserve. Second edition, enlarged and thoroughly revised. Published, 1936. Octavo, 351 pages. Illustrated with 693 engravings. Cloth, $6.50, net.

Based upon the technical discoveries and theories of the pioneers in roentgenology, on clinical reports and on the author's personal experiences, this revised second edition is even more valuable than the first to students and practitioners who wish to perfect their technic in this field. Excellently illustrated chapters on the construction of the Coolidge tube as used in dentistry and the production of the roentgen rays; roentgen-ray dermatosis; intra-oral and extra-oral technic; types, construction and development of films; routine examination of the oral cavity and normal anatomic landmarks of the teeth and jaws, as seen in the roentgenogram, give the reader a clear understanding of these subjects. In addition, the author has devoted the largest chapter in his book to dental pathology in relation to roentgenology, "since there can be no correct interpretation of roentgenograms of acute inflammation involving the teeth and their supporting tissues without an assured and accurate understanding of pathology." One hundred and eleven new engravings have been added to illustrate and supplement the text. The author is to be complimented on the completeness with which he has covered his subject, the quality of the paper and the clearness of the illustrations, as well as on the correctness of his terminology.

M.

The Leica Manual. A manual for the amateur and professional covering the entire field of Leica photography. By Willard D. Morgan, Henry M. Lester and contributors. Price, $4.00. Morgan and Lester, Publishers, New York City, 1935.

Dentists interested in the fascinating and practical art of photography will find in this 500 page manual illustrated with 346 photographs, a complete encyclopedia on the subject. Twenty-nine chapters covering the basic principles of photography including a study of equipment, exposure, developing and printing, prepare the tyro for work in this field. Several chapters deal exclusively with the employment of photography in different branches of science. From the dental point of view, the most instructive chapter has been contributed by A. Laurence Dunn, D.D.S. of Santa Barbara, Calif. Says Dr. Dunn: "Dentistry offers one of the finest fields for the Leica camera in scientific work. With it, the general practitioner, the specialist and the research worker alike will find the opportunity to make records of a remarkable quality." The use of photography for the making and recording of accurate patient records is rapidly becoming more appreciated by the members of the dental profession. Photographs of children receiving orthodontia treatment and of adults requiring dentures are almost essential as a means of comparing the finished results with the original. Nor is there anything that will take the place of the photograph in explaining the technic of many operations. This book, and especially the chapter on dental photography, is recommended to every dentist who is interested in photography, either as a hobby or as a scientific aid to his professional work.

M.

The Human Face. A Symposium. Presented before the Philadelphia County Dental Society in collaboration with the Philadelphia County Medical Society. Price, $2. The Dental Cosmos, Philadelphia, Pa., 1935.

This attractive volume comprises a series of lectures by some of the most advanced men of the day, and its perusal will amply repay the time and effort spent on it.

BOOKS RECEIVED

The National Formulary. Sixth edition. National Formulary VI. N. F. VI. Prepared by the Committee on National Formulary by the authority of the American Pharmaceutical Association. Official from June 1, 1936. Published by the American Pharmaceutical Association, Washington, D. C., 1935.

Report of the Surgeon General U. S. Army to the Secretary of War, 1935. United States Government Printing Office, Washington, 1935. For sale by the Superintendent of Documents, Washington, D. C. Price, 15 cents (paper cover).

The Pharmacopeia of the United States of America. Eleventh Decennial Revision (U. S. P. XI). By authority of the United States Pharmacopeial Convention held at Washington, D. C., May 13 and 14, 1930. Prepared by the Committee of Revision and published by the Board of Trustees. Official from June 1, 1936. Agent, Mack Printing Company, Easton, Pa.

NEWS

Activities at Medical College of Virginia: Edward C. Rosenow, head of the Division of Experimental Bacteriology, Mayo Foundation, will give the McGuire lectures at the Medical College of Virginia April 6 and 7. His subjects will be "Focal Infection and Elective Localization" and "Streptococci in Relation to Diseases of the Nervous System." During the day of April 7 a symposium on focal infections will be conducted by the college faculty. This will cover a wide range of topics.

Grant Van Huysen has joined the staff of the college as associate in anatomy.

The college recently received an anonymous gift of 250 mg. of radium for its hospital division.

L. R. Broster, chief surgeon of the Charing Cross Hospital and prominent endocrinologist of England, was a recent college visitor, lecturing to the students while here.

Beginning with the session 1937-1938, a two-year predental college requirement will become effective in the school of dentistry.

Deaths

Adams, Waldo J., Eugene, Ore.; School of Dentistry, University of Denver, 1906; died January 17.

Bohn, Henry W., Reading, Pa.; University of Pennsylvania School of Dentistry, 1887; died January 16; aged 70.

Cleaver, Harry L., Reading, Pa.; University of Pennsylvania School of Dentistry, 1895; died February 14; aged 70.

Courtright, E. E., Fort Madison, Iowa; Keokuk Dental College, 1903; died February 1; aged 63.

De Vries, Bernard J., Holland, Mich.; University of Michigan, College of Dental Surgery, 1882; died January 5; aged 77.

Ernster, A. G., Dyersville, Iowa; Marquette University, School of Dentistry, 1928; died January 20; aged 30.

Garriott, J. P., Chicago, Ill.; Chicago College of Dental Surgery, 1909; died January 15.

Harbour, Frances Genette, Los Angeles, Calif.; University of Southern California, College of Dentistry, 1903; died February 3; aged 70.

Humpidge, George, Chicago, Ill.; Chicago College of Dental Surgery, 1899; died February 25; aged 57.

Knoll, Howard, Reading, Pa.; Temple University School of Dentistry, 1923; died December 29; aged 38.

McAlister, Humphrey M., Pella, Iowa; State University of Iowa, College of Dentistry, 1885; died January 27.

Minges, Herman, Dubuque, Iowa; Chicago College of Dental Surgery, 1892; died January 25.

Moyles, William J., Manchester, N. H.; University of Tennessee, College of Dentistry, 1903; died February 25; aged 72.

Munroe, Ogden Brown, Springfield, Ill.; School of Dentistry University of Pennsylvania, 1914; died February 10; aged 45.

Walters, Raymond, Holstein, Iowa; University of Iowa, College of Dentistry; died at San Antonio, Texas, January 19.

Watt, Verner W., Chicago, Ill.; College of Dental Surgery, 1909; died January 30; aged 65.

White, David N., Ogden, Utah; Northwestern University Dental School, 1906; died February 6; aged 58.

SAN FRANCISCO—1936 CONVENTION CITY

By SANFORD M. MOOSE, D.D.S.

Greetings! Members of the American Dental Association. Greetings from San Francisco, where the Association's Seventy-Eighth Annual Session will be held, July 13-17.

All San Francisco cordially invites the dentists of America, their wives and families, to partake of the hospitality of this city by the Golden Gate, founded by the adventurers of old Spain, and kindled by the spirit of the Forty-Niners and men who came from trading in the Seven Seas.

San Francisco will thrill you every minute of your stay. Your first sight of the towered hills that rise above the Golden Gate will fill you with a happy sense of romance and adventure that will stay with you as long as you are here. In your first few hours you will see why San Francisco so appeals to men and women with imagination.

The happiest, coolest summer days in all America—rainless, sea-tanged days—and nights that call for blankets on your bed—await you in San Francisco. Cool summer breezes will add zest to your game of golf at Lincoln Park, overlooking the famed Golden Gate strait and its passing ships, or on any one of many other close-in courses.

Our convention will be held in one of the largest halls in the country, the Exposition Auditorium, located in San Francisco's $23,000,000 Civic Center. And San Francisco, with 1,400 hotels, greatest hotel city west of New York, will comfortably take care of us in every other way.

As far as food is concerned, this city's reputation is known to epicures the world over. Here you may dine with gastronomic delight in well-appointed hotel dining rooms; in quaint cafes in the Latin Quarter; in exotic Chinese restaurants, with all the color of the Orient; or in any one of hundreds of other foreign eating places. Scores of night clubs reflect the cosmopolitanism of the city.

Your wives and daughters will be thrilled with the number and variety of shops in San Francisco, many of these fine establishments dating back to gold-rush days. One has the world's finest collection of jade. And this city is a prime market for first-edition books and prints. Chinese stores are museums in themselves.

In later articles, we hope to tell you more about our convention city—intimate sidelights; descriptions of places to visit and suggestions of things to do in San Francisco.

Plan now to attend the Seventy-Eighth Annual Session. Plan to bring your family. Make this year's convention a holiday—never to be forgotten.

San Francisco! July 13 to 17!

ANNOUNCEMENTS*

CALENDAR OF MEETINGS

American Dental Association, San Francisco, July 13-17.

American Academy of Periodontology, San Francisco, July 9-11.

American Academy of Restorative Dentistry, San Francisco, July 11-12.

American Board of Orthodontia, St. Louis, April 17-18.

American Society for the Promotion of Dentistry for Children, San Francisco, July 13-14.

American Society of Oral Surgeons and Exodontists, San Francisco, July 10-11.

Association of American Women Dentists, San Francisco, July 13-17.

American Society of Orthodontists, St. Louis, April 20-23.

National Board of Dental Examiners, May 22-23.

American Dental Society of Europe, August, 1937.

International Dental Congress, Vienna, August 2-8.

Central Pennsylvania Seventh District Dental Society, Johnstown, May 4-6.

Texas-Oklahoma-Dallas County, Dallas, August 31-September 4.

Texas State Dental Society and Texas Association of Oral Surgeons and Exodontists, Dallas, June 8-12.

Society for the Advancement of General Anesthesia in Dentistry, New York City, third Monday in February, April, October and December.

District of Columbia at George Washington University, Washington, D. C., second and fourth Tuesdays in each month from October to June, inclusive.

British Empire Dental Meeting, London, July.

Ontario Dental Association, Toronto, May 18-20.

American Dental Hygienists' Association, San Francisco, July 13-17.

American Dental Assistants Association, San Francisco, July 13-17.

STATE SOCIETIES

April

Alabama, at Birmingham (14-16)
Connecticut, at Stamford (15-17)
Kansas, at Salina (27-29)
Kentucky, at Louisville (6-8)
Louisiana, at Baton Rouge (26-28)
Massachusetts, at Boston (28-May 1)
Michigan, at Detroit (20-22)
Mississippi, at Greenville (13-15)
Montana, at Butte (16-18)
New Jersey, at Atlantic City (22-24)
Washington, at Seattle (30-May 2)
Wisconsin, at Milwaukee (21-23)

May

Arkansas, at Little Rock (11-13)
Georgia, at Atlanta (11-13)
Illinois, at Peoria (12-14)
Indiana, at Indianapolis (18-20)
Iowa, at Des Moines (5-7)
Maryland, at Baltimore (4-6)
Nebraska, at Lincoln (18-20)
New York, at New York City (12-15)
North Carolina, at Pinehurst (11-13)
North Dakota, at Bismarck (7-8)
Tennessee, at Memphis (4-6)
South Dakota, at Sioux Falls (4-6)
Utah, at Salt Lake City (21-23)
Vermont, at Burlington (13-15)
Virginia, at Roanoke (4-6)
West Virginia, at Fairmont (18-20)

June

Colorado, at Denver
Maine, at Portland (26-27)
Missouri, at St. Louis (8-10)
New Hampshire, at Sunapee (29-30)

July

Wyoming, at Sheridan (13-14)

September

Southern California, at Los Angeles (21-23)

*Announcements must be received by the fifth day of the month in order to be published in the forthcoming issue of THE JOURNAL.

October

Florida, at Orlando (5-7)

November

Puerto Rico, at Mayaguez

STATE BOARDS OF DENTAL EXAMINERS

Alabama, at Birmingham, June 29. E. W. Patton, Comer Bldg., Birmingham, Secretary.

Arkansas, at Little Rock, June 15-18. Clarence W. Koch, Donaghey Bldg., Little Rock.

California, at Los Angeles, June 15, and at San Francisco, May 25. Kenneth I. Nesbitt, 450 McAllister St., San Francisco, Secretary.

Colorado, June 23-27. David J. Tepley, 807 Republic Bldg., Denver, Secretary.

Connecticut, at Hartford, June 23-27. Almond J. Cutting, Southington, Recorder.

Delaware, June 17-18. Charles R. Jefferis, Wilmington, Secretary.

Florida, at Jacksonville, June 22-26. H. B. Pattishall, 351 St. James Bldg., Jacksonville, Secretary.

Indiana, at Indianapolis, June 16-19. J. M. Hale, Mt. Vernon, Secretary.

Kentucky, June 5-8. Robert L. Sprau, 970 Baxter Ave., Louisville, Secretary.

Louisiana, at New Orleans, June 10-13. Joseph L. Webre, New Orleans, Secretary.

Maine, at Augusta, June 22-24. Alton H. Swett, 192 State St., Portland, Secretary.

Mississippi, at Jackson, June 16. T. Ford Leggett, Laurel, Secretary.

New Jersey, June 29-July 4. John C. Forsyth, 148 W. State St., Trenton, Secretary.

New Mexico, at Albuquerque, June 22-24. J. J. Clarke, Artesia, Secretary.

North Dakota, at Fargo, July 14-17. W. E. Cole, Bismarck, Secretary.

Ohio, at Columbus, June 22. Morton H. Jones, 1553½ North Fourth St., Columbus, Secretary.

Pennsylvania, at Philadelphia and Pittsburgh, W. A. McCready, Highland Bldg., Harrisburg, Secretary.

South Carolina, at Columbia, June 15-17. David Aiken, Winnsboro Bank Bldg., Winnsboro, Secretary.

Texas, at Houston, June 15-18. R. T. Weber, Norwood Bldg., Austin, Secretary.

Vermont, at Montpelier, June 29-July 1. H. B. Small, Burlington, Secretary.

Virginia, at Richmond, June 9. John M. Hughes, Medical Arts Bldg., Richmond, Secretary.

West Virginia, June 29-July 1. Henry C. Hill, 804 Quarrier St., Charleston, Secretary.

Wisconsin, at Milwaukee, June 15-19. S. F. Donavan, Tomah, Secretary.

NORTH DAKOTA STATE DENTAL SOCIETY

(Change of Dates)

The next meeting of the North Dakota State Dental Society will be held May 7-8 instead of May 11-13, as previously announced; at Bismarck.

RUSSELL A. SAND, *Secretary,*
Fargo.

NATIONAL BOARD OF DENTAL EXAMINERS

The National Board of Dental Examiners will hold examinations May 22-23 for candidates taking Parts I and II. Sessions will be held in schools where there are five or more candidates. Circulars of information and application blanks can be obtained from the secretary, Morton J. Loeb, 66 Trumbull St., New Haven, Conn.

BOARD OF DENTAL EXAMINERS OF ALABAMA

The Board of Dental Examiners of Alabama will conduct its next annual dental and dental hygiene examinations in Birmingham commencing at 8:30 a.m., June 29. Failure to forward all credentials to the secretary's office at least two weeks before the date of commencement of examinations will have the effect of barring the applicant from examination. For further information, address

E. W. PATTON, *Secretary,*
1807 Comer Bldg.,
Birmingham.

ARKANSAS STATE BOARD OF DENTAL EXAMINERS

The next examination of applicants to practice dentistry in Arkansas will be held at the Marion Hotel, Little Rock, June 15-18; fee, $35. Applications must be filed at least ten days prior to date of examination. Address all communications for further particulars to

CLARENCE W. KOCH, *Secretary,*
817 Donaghey Bldg.,
Little Rock.

DELAWARE STATE BOARD OF DENTAL EXAMINERS

The Delaware State Board of Dental Examiners will hold examinations for the practice of dentistry in Delaware, June 17-18.

CHARLES R. JEFFERIS, *Secretary,*
Wilmington.

LOUISIANA STATE BOARD OF DENTISTRY

The next examinations to be conducted by the Louisiana State Board of Dentistry for license to practice dentistry and dental hygiene in Louisiana will be held in New Orleans at the Loyola University, June 10-13. On application to the secretary, an instruction sheet and an application blank will be sent. All credentials must be in the office of the secretary before May 10.

JOSEPH L. WEBRE, *Secretary,*
New Orleans.

NEW MEXICO BOARD OF DENTAL EXAMINERS

The next meeting of the New Mexico Board of Dental Examiners will be held at Albuquerque, June 22-24. For further information, apply to

J. J. CLARKE, *Secretary,*
Artesia.

PENNSYLVANIA STATE BOARD OF DENTAL EXAMINERS

The Pennsylvania State Board of Dental Examiners will hold its next examinations June 9-13 at Philadelphia and Pittsburgh.

W. A. MCCREADY, *Secretary,*
1115 Highland Bldg.,
Harrisburg.

TEXAS STATE BOARD OF DENTAL EXAMINERS

The next examination of the Texas State Board of Dental Examiners will be held in Houston, June 15-18. There is no reciprocity. Applications must be filed at least ten days prior to the date of examination. Address all communications for further particulars to

R. T. WEBER, *Secretary,*
1014 Norwood Bldg.,
Austin.

VERMONT STATE BOARD OF DENTAL EXAMINERS

The Vermont State Board of Dental Examiners will meet June 29-July 1 in the State House, Montpelier, to examine applicants for license to practice dentistry and dental hygiene. All applications, accompanied by the examination fee, must be in the hands of the secretary at least fifteen days before the date of the meeting. For applications and other information, address

H. B. SMALL, *Secretary,*
Burlington.

VIRGINIA STATE BOARD OF DENTAL EXAMINERS

The next regular meeting of the Virginia State Board of Dental Examiners will be held at the Medical College of Virginia, Richmond, beginning promptly at 9 a.m., June 9. Applicants are required to present a certificate from the Virginia State Board of Education showing that they have had one year of academic education equal to one year of college work, must be graduates of a Class A or B dental college or university and must be prepared to do any kind of practical or operative work necessary in the general practice of dentistry. Theoretical examinations cover subjects usually found in a complete dental curriculum. Applications, with fee and photograph, must be filed, complete, fifteen days before the examination. For application blanks and further information, apply to

JOHN M. HUGHES, *Secretary,*
715 Medical Arts Bldg.,
Richmond.

WISCONSIN STATE BOARD OF DENTAL EXAMINERS

The next examination of the Wisconsin State Board of Dental Examiners will be held at Marquette University, Milwaukee, June 15-19. Applications must be in the secretary's office ten days before examination. For further information, address

S. F. DONAVAN,
Tomah.

TEXAS JOINT MEETING

The fifty-sixth annual convention of the Texas State Dental Society will be held jointly with the annual meetings of the Oklahoma State Dental Society and the Dallas County Midwinter Dental Clinic, in conjunction with the Texas Centennial Central Exposition, in Dallas, August 31-September 4.

P. J. MURPHEY,
3702 Fairmount St.,
Dallas.

ASSOCIATION OF AMERICAN WOMEN DENTISTS

The Association of American Women Dentists will be held in San Francisco, July 13-17.

VIRGINIA TREMBLY, *Chairman,*
Publicity Committee,
317 Burns Bldg.,
Colorado Springs, Colo.

AMERICAN SOCIETY FOR THE PROMOTION OF DENTISTRY FOR CHILDREN

The next annual meeting of the American Society for the Promotion of Dentistry for Children will be held in the St. Francis Hotel, San Francisco, Calif., July 13-14.

JOHN C. BRAUER, *Secretary,*
College of Dentistry,
University of Nebraska,
Lincoln, Nebr.

AMERICAN ACADEMY OF RESTORATIVE DENTISTRY

The American Academy of Restorative Dentistry will hold its meeting in the Gothic Room of the Sir Francis Drake Hotel, San Francisco, Calif., July 11-12.

A. F. SCHOPPER, *Secretary,*
Professional Bldg.,
Kansas City, Mo.

AMERICAN ACADEMY OF PERIODONTOLOGY

The twenty-third annual meeting of the American Academy of Periodontology will be held at the Palace Hotel, San Francisco, Calif., July 9-11.

CLAYTON H. GRACEY, *Secretary,*
Fisher Bldg.,
Detroit, Mich.

AMERICAN SOCIETY OF ORAL SURGEONS AND EXODONTISTS

The eighteenth annual meeting of the American Society of Oral Surgeons and Exodontists will be held at the Sir Francis Drake Hotel, San Francisco, Calif., July 10-11.

HARRY BEAR, *Secretary,*
410 Professional Bldg.,
Richmond, Va.

CENTRAL PENNSYLVANIA SEVENTH DISTRICT DENTAL SOCIETY

The thirty-fourth annual session of the Central Pennsylvania Seventh District Dental Society will be held in the Fort Stanwix Hotel, Johnstown, May 4-6.

R. M. WOLFORD, *Chairman,*
Publicity Committee,
601 Johnstown Trust Bldg.,
Johnstown.

WESTERN RESERVE UNIVERSITY SCHOOL OF DENTISTRY ALUMNI

The Western Reserve University School

of Dentistry Alumni will meet June 8 at the school, for lectures and clinics in the afternoon, and in the evening for dinner and entertainment at the University Club.

LEON E. NEWMAN, *Secretary.*

CLASS OF 1931 SCHOOL OF DENTISTRY UNIVERSITY OF MARYLAND

An anniversary dinner of the class of 1931 of the School of Dentistry of the University of Maryland will be held June 4 in Baltimore.

ALBERT ESKIN,
Reunion Committee,
2023 Eutaw Place,
Baltimore.

EXAMINATION FOR INTERNSHIPS

A competitive examination will be held April 11 at the Queens General Hospital to fill two vacancies for dental internships. Candidates must have graduated from a dental school registered by the regents of the University of the State of New York. Service will begin July 1, 1936, and will terminate June 30, 1937. The Queens General Hospital is a new active general city hospital, a unit of the Department of Hospitals of the City of New York. The hospital has a capacity of 636 beds, which include fifty-four beds devoted to contagious diseases and offers excellent opportunities in dental training. There is no salary connected with the internship. Full maintenance is provided. Write for application blanks to the Medical Superintendent of the Queens General Hospital, Jamaica, L. I. Applications will be received until April 6, 5 p.m.

MARCUS D. KOGEL, M.D.,
Medical Superintendent,
Queens General Hospital,
Jamaica, L. I.,
New York.

AMERICAN DENTAL HYGIENISTS' ASSOCIATION

The thirteenth annual meeting of the American Dental Hygienists' Association, Inc., will be held in San Francisco, Calif., July 13-17, with headquarters at the William Taylor Hotel.

AGNES G. MORRIS, *Secretary,*
886 Main St.,
Bridgeport, Conn.

AMERICAN DENTAL ASSISTANTS ASSOCIATION

The twelfth annual meeting of the American Dental Assistants Association will be held in San Francisco, Calif., July 13-17, with headquarters at the Hotel Whitcomb. For further information, address

LUCILE S. HODGE, *General Secretary,*
401 Medical Arts Bldg.,
Knoxville, Tenn.

PHILADELPHIA ASSOCIATION OF DENTAL NURSES

The regular monthly meeting of the Philadelphia Association of Dental Nurses will be held in the Medical Towers Bldg., April 21, 8 p.m.

CATHERINE G. CONNER, *Chairman,*
Publicity Committee,
Germantown, Pa.

PHILADELPHIA DISTRICT DENTAL HYGIENISTS' ASSOCIATION

The regular monthly meeting of the Philadelphia District Dental Hygienists' Association will be held in the Rittenhouse Hotel Clinic Club Rooms, April 27 at 8:15 p.m., with dinner at the Stephen Girard Hotel at 6:30.

MAE SARSFIELD, *President,*
Professional Bldg.,
Germantown, Pa.

AMERICAN DENTAL ASSOCIATION

San Francisco, Calif. July 13-17, 1936.

HOTEL RESERVATION

In securing hotel reservations for the 1936 Session, consult the hotel rate sheet and fill out the blank application below. Mail immediately to the hotel you wish to patronize. The hotel will then advise you of the reservation that they make for you.

In case your first choice cannot be made, please indicate second and third choices. If none of your choices are available, the hotel manager will mail your application to the chairman of the Halls & Hotels Committee and he will place your reservation in as favorable a hotel as possible.

Please remember that a reservation constitutes a contract with the hotel to provide you with the accommodations you desire. If you find it impossible to carry out your part of the contract, namely, to occupy the room at the time agreed on, write or wire the hotel, releasing it in order that your room may be available for other members.

MAIL THIS APPLICATION DIRECT TO THE HOTEL

HOTEL RESERVATION

AMERICAN DENTAL ASSOCIATION, SAN FRANCISCO, CALIF., JULY 13-17, 1936.

.....Hotel.

San Francisco, Calif.

Please reserve sleeping accommodations as noted below:

.....Room(s) With bath for.....persons. Rate desired $.....

.....Room(s) Without bath for.....persons. Rate desired $.....

Third choice hotel..... Second choice hotel.....

ROOMS TO BE OCCUPIED BY: ADDRESS IN FULL

Applicant..... .....

....

....

....

Please confirm this reservation to applicant. I further agree to notify the hotel at once in the event I am unable to use this reservation.

IMPORTANT TO HOTEL MANAGER: In the event you cannot accept this reservation, please forward this application at once to Dr. C. W. Johnson, Chairman, Halls & Hotels Committee, 1160 Flood Bldg., San Francisco, Calif., who will attend to the assignment of this reservation.

HOTEL	WITH BATH		
	One Person	Two Persons	Twin Beds
ALEXANDER HAMILTON 631 O'Farrell St.			$6.50 Apts.
AMBASSADOR HOTEL Mason & Eddy Sts.	$2.50	$3.50	4.50
BRAYTON 50 Turk St.	2.00	2.50–3.00	3.50
CALIFORNIAN 405 Taylor St.	3.00	4.00	5.00
CLARK 217 Eddy St.	2.50–3.00	3.00	3.50
CLIFT Geary at Taylor St.	3.50	5.00	5.00–6.00–7.00 8.00–9.00
EL CORTEZ 550 Geary St.	3.00–3.50 4.00	4.50	5.00–6.00
FAIRMONT HOTEL California & Mason Sts.	3.50–4.00 5.00–6.00	5.00–6.00 7.00	6.00–8.00 10.00
FIELDING Geary & Mason Sts.		3.00	3.50
GAYLORD 620 Jones St.	2.50–3.00	3.50–4.00	4.00–5.00
HERBERT'S 151 Powell St.	1.50*	2.50*	
HOTEL BELLEVUE Geary & Taylor Sts.	2.50–3.00 3.50	3.50–4.00 4.50	4.50
HOTEL CANTERBURY 750 Sutter St.	3.00–3.50	4.50–5.50	4.50–5.50
HOTEL FRANCISCAN 350 Geary St.	2.50	3.50–4.00	4.50
HOTEL MANX 225 Powell St.	2.50	3.50–4.00	
HOTEL MAURICE 761 Post St.	3.00–3.50	4.50–5.50	5.50–6.50
HOTEL SENATOR 519 Ellis St.	2.00	2.50	3.00

*Without Bath Only.

HOTEL	WITH BATH		
	One Person	Two Persons	Twin Beds
HOTEL STEWART 353 Geary St.	2.50–3.00 3.50	4.00–4.50 5.00	4.00–4.50 5.00
HOTEL UTICA 333 Fulton St.	2.00–2.50	2.50–3.00	3.50–4.00
KING GEORGE 334 Mason St.		3.00–4.00	
MARK HOPKINS 999 California St.	4.00–5.00 6.00–7.00	6.00–7.00 8.00	7.00–8.00 9.00–10.00
MARYLAND 490 Geary St.	2.50	3.00	
OLYMPIC HOTEL 230 Eddy St.	2.50	3.50	4.00
OXFORD Mason & Turk Sts.		3.00	4.00
PALACE Market & New Montgomery Sts.	3.00–3.50–4.00 5.00–6.00	5.00–6.00 7.00	6.00–7.00 8.00
PLAZA 310 Post St.	2.00	3.00–3.50 4.00	4.50–5.00
PICKWICK 5th & Mission Sts.	2.50–3.00	3.50–4.00	4.50–5.00
RAMONA 174 Ellis St.		3.00	4.00
ST. FRANCIS Powell & Geary Sts.	3.50–4.00 5.00–6.00	5.00–6.00 7.00–8.00	6.00–7.00 8.00–10.00
SHAW 1112 Market St.	2.50	3.50	4.00
SIR FRANCIS DRAKE Sutter & Powell Sts.	3.00–3.50 4.00–5.00	5.00–6.00 7.00	6.00–7.00 8.00–9.00
SPAULDING 240 O'Farrell St.	2.00	3.00	
WHITCOMB 1231 Market St.	2.00–2.50–3.00 3.50–4.00	3.00–3.50 4.00	4.00–4.50 5.00–6.00
WILLIAM TAYLOR 100 McAllister St.	2.50–3.00 3.50	3.50–4.00	4.00–5.00 6.00

AMERICAN DENTAL ASSOCIATION

78TH ANNUAL SESSION

SAN FRANCISCO

JULY 13-17

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Presentation and Discussions
on
Dental Economic Problems

• •

LATEST INFORMATION ON DENTAL AND ALLIED SUBJECTS BY LEADING AUTHORITIES

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1935-1936

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